KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
KUMASI

SCHOOL OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

A STUDY OF THE EFFECT OF COMPACTION ON PARTICLE BREAKAGE OF SUB-BASE AND BASE MATERIAL USED FOR PAVEMENT CONSTRUCTION IN GHANA

A thesis submitted to
The Board of Postgraduate Studies
Kwame Nkrumah University of Science and Technology, Kumasi.
In Partial fulfillment of the requirement for the award of the
Degree of Master of Philosophy in Civil Engineering

BY
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ABSTRACT

The acquisition of naturally occurring soils for construction purposes involves first taking soil samples from trial pits in proposed borrow pits and testing them in the laboratory. In actual field practice, contrary to specification the results obtained from the said laboratory test are then compared with the as placed and compacted material requirements of the MRH specifications for road and bridge works after which the suitability of the soil material is decided.

Some selected soil samples from the three agro-ecological zones of Ghana were used for laboratory, model site and field compaction studies. The laboratory compaction method used was the modified ASSHTO T 190. The model site compaction studies involved three loose lift beds of 120 mm, 170 mm and 220 mm and three types of compaction plants; an 825kg duplex vibratory roller, 8,559kg static roller, and 15,380kg vibratory roller. The field compaction studies used a number of field compaction plants.

The analysis used the decrease in gravel content as an index of particle breakage. It was generally observed that particle breakdown occurred for all the soil samples studied under both laboratory and field compaction. The extent of particle breakdown, however, was different for different soils and varied from a minimum of 1% to a maximum of 19% decrease in gravel content. In the laboratory, particle breakdown was observed to take place only during the initial stages of compaction. The breakdown of particles did not significantly affect the Atterberg limits and tended to lead to increase in strength of the compacted soils.

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DEDICATION

To my late father Mr. Thomas Robertson Baidoo Arthur, who had so much desired to see me come this far in my education before passing away. May his soul, rest in perfect peace.

And

My wife (Elly) and the Children: Ekow, Ewurasi, Ewurabena and Kukua; they had to miss me a lot during this study period.

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1. INTRODUCTION

1.1 BACKGROUND TO THE STUDY

For the majority of roads in Ghana the sub-base and base layers are built with naturally occurring soil material. For example, Figure 1.1 shows some typical road sections commonly found in Ghana. The current standard specifications of the Ministry of Roads and Highways (MRH, 1991) for road works require that naturally occurring soil material intended for the construction of sub-base, and base course layers in road pavements meet the requirements stipulated in clause 12.3. These requirements which have been summarized in Table 1.1 include grading, Atterberg limits, bearing strength (CBR), and the strength of coarse particles, as the material characteristics and restrictions most relevant for the satisfactory performance of natural gravels in road pavements works.

The grading bands suggested in Table 1.1 are typical and reveal a trend to push the grading towards the continuous Fuller curve (Millard; 1993 and Charman; 1995), derived based upon considering the maximum particle size and using the proportion rule:

$$\%\ \text{passing the test sieve} = 100 \times \sqrt{\frac{\text{Apperture size of test sieve}}{\text{Size of largest particle}}}$$

The fundamental objective here is the selection of a grading band that ensures a mechanically stable grading which facilitates high compacted density and also allows the finer particles to support the coarser particles, so that applied loads are not borne wholly by relatively few point-to-point grain contacts within the laid pavement structure. The grading specified, however, effectively limit potentially suitable natural materials to gravely or nodular laterite or to such honeycomb and hardpan laterites, which can be processed to the required grading with little effort.

Plasticity Index, Liquid Limit, and Plasticity Modulus have also been specified as a check against the susceptibility of compacted pavement materials to volume changes that may arise due to seasonal moisture variations (Charman; 1995). Plasticity Modulus is defined as the product of plasticity index and percentage of material passing the 425-micron sieve.

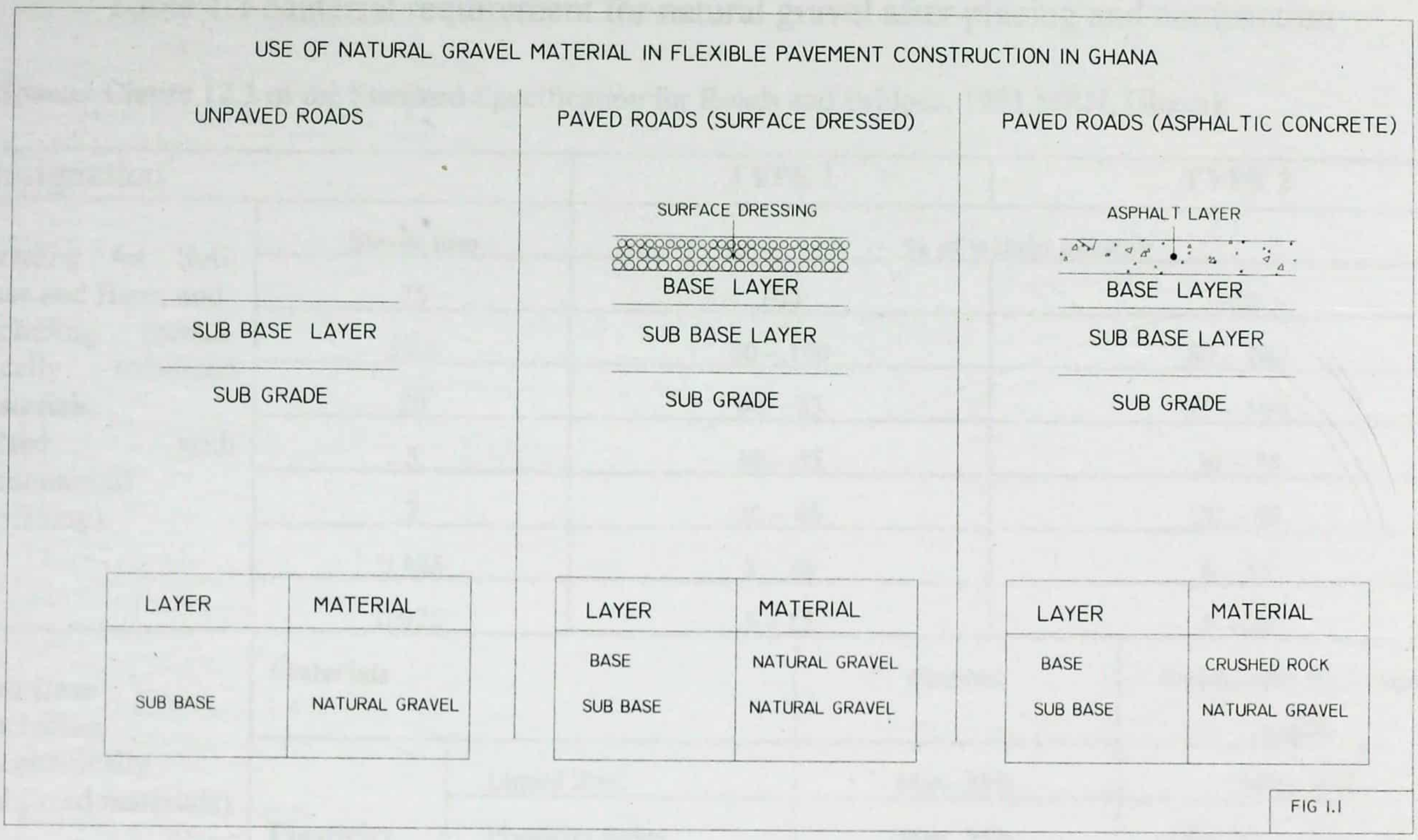

Figure 1.1 Use of natural material in Flexible Pavement Construction in Ghana

In Ghana, the California Bearing Ratio(CBR) test is the standard test for the determination of the bearing capacity of compacted pavement materials. The test though empirical, is widely known and accepted. It is also simple, easy and inexpensive to perform.

The acquisition of naturally occurring soils for construction purposes, often follows the sequence of first identifying suitable material sources by visual assessment based upon grading and designating the material sources as proposed borrow pits. Soil samples are then acquired from trial pits in the proposed borrow pits and tested in the laboratory. The results obtained in the laboratory test are then compared with the requirements of MRH Specification and the suitability of the material for its intended purpose is determined.

For a pit found satisfactory at this stage, a formal acquisition is made and it becomes designated as a borrow pit. Afterwards, the overburden layer is stripped off, the material stockpiled, loaded into trucks and transported to the construction front, where it is spread, laid and compacted. It is in this condition that the material should meet the requirements of the specification. But, in actual practice, the as placed soils are not checked as required. The current field practice, therefore, equates the material in its unprocessed state (borrow pit condition) to the processed (as ~~– placed –~~ and compacted) condition. The underlying

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Table 1.1 Material requirement for natural gravel after placing and compaction

(Source: Clause 12.3 of the Standard Specification for Roads and Bridges, 1991,MRH, Ghana).

Designation			TYPE 1	TYPE 2
Grading for Sub-base and Base; and including mechanically stabilized materials. (Used with bituminuous surfacing).	**Sieves mm**		**% of weight passing**	
	75		100	100
	37.5		80 – 100	80 – 100
	20		60 – 85	75 – 100
	5		30 – 55	30 – 75
	2		20 – 45	20 – 50
	0.425		8 – 26	8 – 33
	0.075		5 – 15	5 – 22
Sub-base (including mechanically stabilized materials)	**Materials**		**Gravels**	**Sands, silty and clayey sands**
	Plasticity	Liquid limit	Max. 35%	Max. 35%
		Plasticity Index	Max. 15%	Min. 5% – Max. 12%
		Plasticity Modulus	Max. 250	Max. 250
	Grading	Max. Size	75mm	-
		Uniformity Coefficient	Min. 5	Min. 5
		% passing 2 mm sieve	-	Max. 95%
		% passing 0.075 mm sieve	-	Min. 10 – Max. 30%
	Strength	CBR – 95% MDD, 4 day soak.(AASHTO)	Min.40%	Min.40%
		10% Fines (Wet)	Min. 50KN	Min. 50KN
Base (including mechanically stabilized materials)	**Materials**		**TYPE 1**	**TYPE 2**
	Plasticity	Liquid limit	Max. 25%	Max. 30%
		Plasticity Index	Max. 10%	Max. 15%
		Plasticity Modulus	Max. 200	Max. 400
	Strength	Los Angeles Abrasion	Max. 50%	Max. 50%
		Aggregate Crushing Value	Max. 35%	Max. 35%
		10% Fines (Wet)	Min. 50KN	Min. 50KN
		CBR – 95% MDD, 4 day soak.(AASHTO)	Min.80%	Min. 60%
	Note: For the base, Type 2 requirements are for use with surface dressing only and where traffic levels do not exceed 300 equivalent standard axles (8200 kg) per day.			

assumption in this procedure is that the essential properties of the soil material after it has gone through the process of stockpiling, loading, transportation, spreading and compaction do not experience any significant change.

This study seeks to contribute towards a better understanding of the effect of compaction in modifying the properties of base/sub-base material during road construction in Ghana.

1.2 OBJECTIVES OF STUDY

The objective of this study may be stated explicitly as:

(1) To evaluate the effect of laboratory compaction on particle breakage of selected gravel material and how this depends on compactive effort, and the influence of such particle breakage on strength as measured by CBR.

(2) To evaluate the effectiveness of various compaction plant in achieving the required levels of compaction and the effect of such plant on particle breakage on a Model Construction Site.

(3) To evaluate the level of particle breakage experienced in actual road construction works.

1.3 JUSTIFICATION OF STUDY

Pavement engineers and road users have always desired to have constructed, pavements which are properly designed and capable of meeting their designed level of performance. This will often mean ensuring good sub-grade material surveys. It will also mean the use of sound material meeting specification requirements and ensuring proper quality control measures during construction.

Of the various operations involved in the processing of natural gravel materials used for sub-base and base layer construction, compaction is perhaps the activity most likely to effect most changes in the material properties. Studies on some laterite soils, both local (Hammond, 1970; Gidigasu and Dogbey, 1980; and Ahiamadi, 1997), and abroad (Sandford et al, 1980), have shown that substantial particle breakdown may take place under either laboratory compaction or field compaction. The breakdown of particles during laboratory compaction has been

reported by Hammond (1970) as affecting the strength properties of the soil material in terms of California Bearing Ratio (CBR). This suggests that the use of high levels of compaction demanded by project specifications may lead to some degree of pulverization which could affect performance of the material as a pavement layer material.

The extent of particle breakdown has also been noted to be different for different soils under the same compactive effort, (Gidigasu and Dogbey, 1980; Ahiamadi, 1997; and Sandford et al, 1980). In Ghana, lateritic soils used for sub-base and base layers originate from the weathering of different rock formations found within different climatic and vegetative environments. Thus these soils are likely to exhibit different goetechnical properties after compaction as suggested by Fookes (1997).

In addition, the extent of particle breakdown for the same soil material has also been observed to be different for different compactive efforts (Gidigasu and Dogbey, 1980; Sandford et al, 1980 and Ahiamadi, 1997). Thus, information on the extent to which local soils break down under both laboratory and field compaction, the broad distribution of such soils in the country, and the range of compactive efforts under which such breakage takes place, are essential for proper selection of compaction technology.

1.4 SCOPE OF STUDY

The studies comprised a literature review, laboratory tests and field work. **The literature review** covered a review of available information on the geology of Ghana, weathering of rocks, formation of laterite soils, the rainfall, topography, and the Agro – Ecological zones of Ghana. A review on the mechanism and principles of soil compaction, the compacted soil structure, compaction plant and laboratory compaction methods were also made. The review also covered the effect of compaction on particle size distribution, plasticity and strength, as well as the effect of moulding water content on particle breakage.

Laboratory studies were carried out in three phases. The first phase involved running two sets of classification test on each set of the raw soil samples brought to the laboratory. The second phase consisted of compacting the soil samples to various blows (10, 25 and 55 blows) and thereafter testing them for classification and where appropriate CBR (soaked and unsoaked). The third phase involved running classification tests on various compacted soil samples

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brought to the laboratory from a model pavement test site, and also from some actual pavement construction sites in the three Agro-ecological zones of Ghana.

Field studies were carried out in two phases. The first phase covered studies on a model pavement test site, which formed part of the approach road to the River Kusu bridge, on the Tepa – Goaso road, in the Ahafo-Ano North district of the Brong –Ahafo region. Three compaction plant, an 825kg vibrating duplex, an 8,559kg static roller, and a 15,380kg vibrating roller were employed on specially prepared pavements of targeted compacted thickness of 100mm, 150mm and 200mm respectively. After every 2 passes up to 12 passes per roller per pavement bed in-situ density and DCP (CBR) test were carried out on the pavement. Also un-compacted and compacted soil samples were taken to the laboratory for classification test. The soil material employed in the test consisted of laterite soil with a high proportion of slightly weathered rock fragments, thus making it a suitable base material. The second phase of the studies was carried out on actual pavement project sites selected from three defined agro ecological zones. The number of passes made by the rollers and the level of compaction achieved during actual field compaction were also examined.

2. REVIEW OF THE SOILS OF GHANA

2.1 The Geology of Ghana

The various rock formations, as well as their distribution in Ghana, are shown in Figure 2.1. Precambrian rocks are the main rock formations found in Ghana. These rocks, metamorphosed and folded, with their associated differentiates and basic intrusives cover about 60% of the country. They consist of the Birrimian, Tarkwaian, Dahomeyan systems, the Togo series, and the Buem Formation. Intruded into the Birrimian rocks are, large masses of granotoids known as the Cape Coast and Winneba (G.1) rock types, smaller masses of granotoids known as Dixcove type (G.2), and, the rare Bongo potassic granotoids found mainly in the northeast side of the country. The Voltaian Series of sandstone, shale, mudstones, arkoses, conglomerate, tillite and limestone, underlie the remaining 40% of the country. However, rocks of the Devonian, Upper Jurassic and Cretaceous-Eocene formations occur at several places along the coast of the country (Bates and Wills; 1962, Morin et al; 1971 and Kesse; 1985).

2.2 Weathering of Rocks

2.2.1 *Physical Weathering*

A profile of residual soil material (see Figure 2.2) lying above the unweathered rock often shows the transitional stages of soil formation. Downward from the surficial zone of soil, progressively lesser degrees of rock weathering and soil formation exist, until finally the unaltered rock is encountered. Physical and chemical processes of weathering are the two main processes most relevant to the formation of soils. Physical process of weathering includes such mechanical actions as abrasion, expansion, and contraction. Angular blocks, cobbles, gravel, sand, silt, and even clay-sized rock flour are some of the end products of physical weathering; but these generally maintain the mineral constituents of the parent rock.

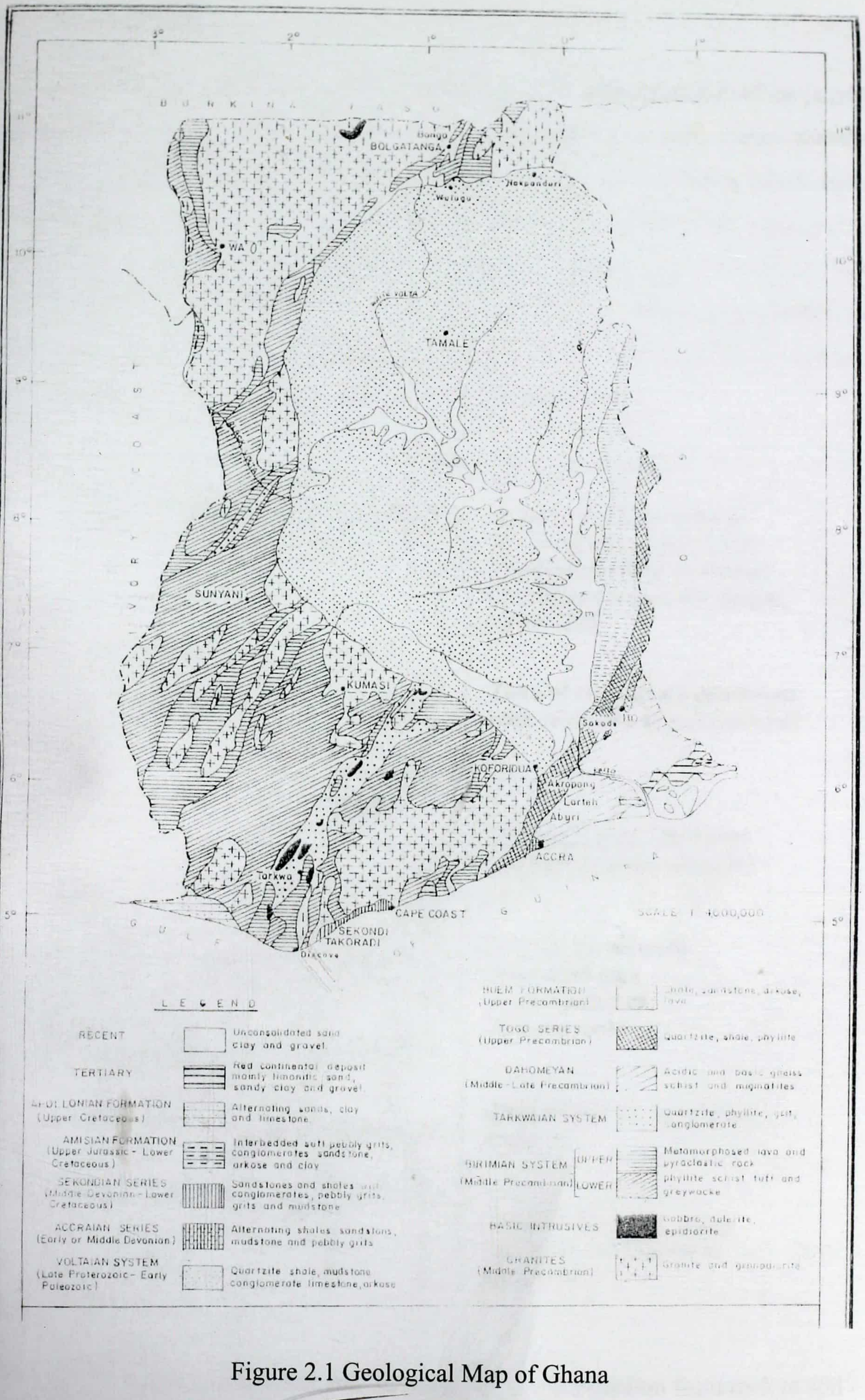

Figure 2.1 Geological Map of Ghana

Source: Soil Research Institute, Kwadaso

2.2.2 *Chemical Weathering*

Chemical weathering process, on the other hand, involves the decomposition of the parent rock or its fragments leading to the formation of new minerals. Water, oxygen, carbon dioxide, and organic acids derived from vegetation are the leading agents of weathering which enter into chemical reactions with the primary minerals of the parent rock. Some of the various chemical processes which take place include hydration, hydrolysis, solution and carbonation (Lutgens, F.K. and Tarbuck, E.J.; 1993). Thus the occurrence of chemical weathering processes is aided by the abundance of moisture and warm temperatures. However, the chemical reaction rates approximately doubles with each 10°C rise in average temperature.

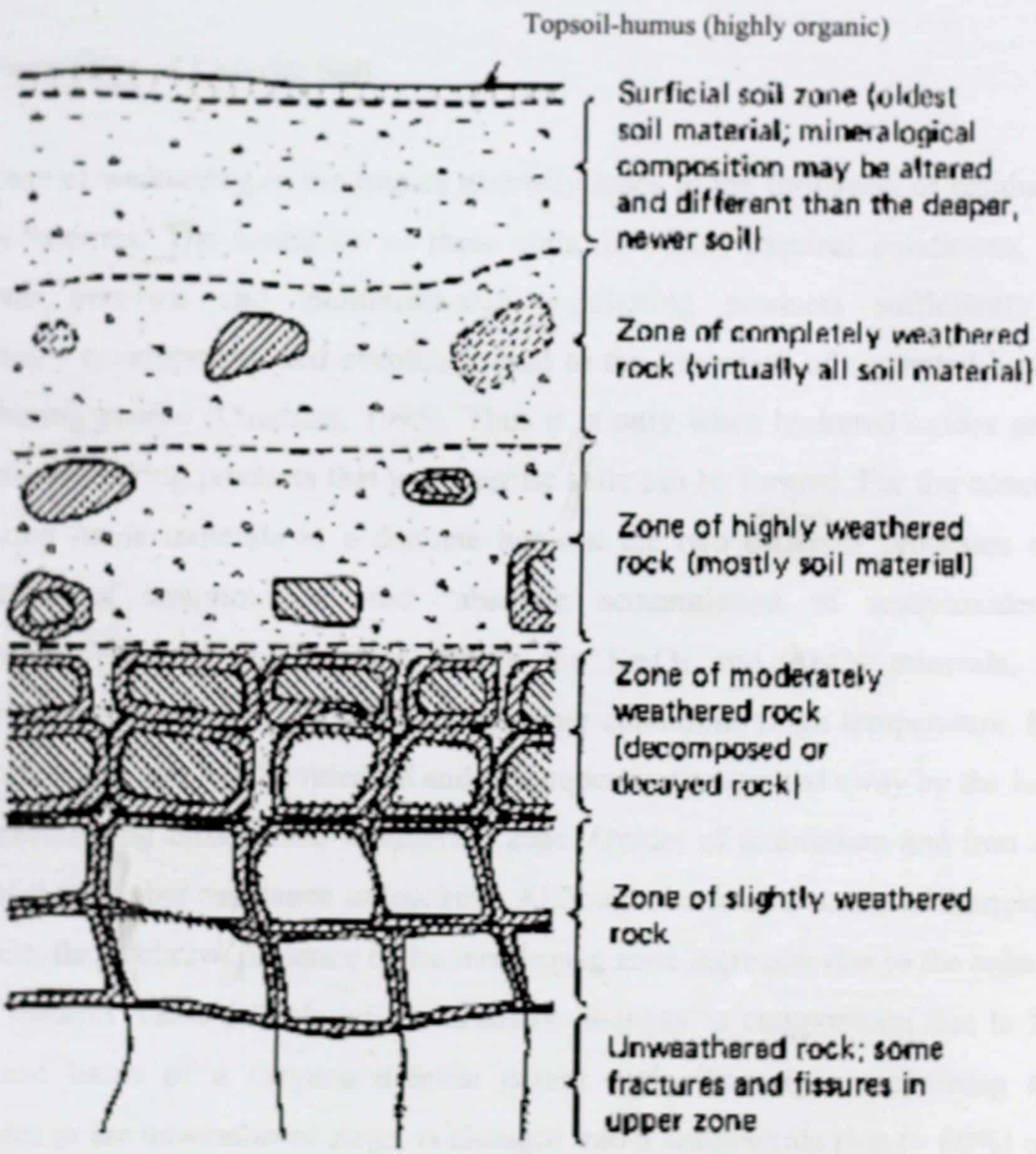

Figure 2.2 Profile of residual soil including stages of transition from rock to soil

After McCarthy, DF 1993

Figure 2.3 illustrates the processes involved in the formation of laterites through weathering. It also illustrates the various chemical changes experienced during the weathering of igneous and metamorphic rocks in a tropical environment. The figure again illustrates the weathering order of the different minerals, from high propensity for basic minerals to extreme stability for acidic quartz. The figure shows also that different parent rocks have different susceptibility to breakdown by weathering. The list and order of the minerals shown in this figure is identical with the Bowens reaction-series (Lutgens / Tarbuck, 1993), which is derived from the order in which minerals crystallize from a cooling magma. Thus, the first minerals to be created are unstable and show the most pronounced weathering, whereas the last minerals to crystallize are highly stable and show the slowest rate of weathering.

2.3 Formation of Laterite Soil

The process of weathering in the tropics normally leads to the formation of residual soils and finally to laterites. The formation of these soils, however, requires conditions, which will concentrate iron-rich and aluminium-rich weathering products sufficiently to allow concretionary development, and eventually lead to the formation of cemented horizon within the weathering profile (Charman, 1995). Thus it is only when hydrated oxides and kaolinite develop as weathering products that true lateritic soils can be formed. For the concentration of the hydrated oxide minerals in a discrete horizon the two different processes of "relative accumulation of sesquioxides" and "absolute accumulation of sesquioxides" can be distinguished. The sesquioxides are simply the Fe_2O_3 and Al_2O_3 minerals, which had accumulated in the soil. In the extreme weathering conditions (high temperature, high annual rainfall) much silicium will be released and subsequently transported away by the large amount of water percolating through the weathering zone. Oxides of aluminium and iron stay behind because of their higher resistance to leaching. Although the total quantity of sesquioxides does not increase, their relative presence in the weathering zone increases due to the reduction of the total soil volume. Table 2.1, shows the dramatic changes in composition due to leaching of silicium and bases of a Guyana dolerite parent rock. The rock, containing about 30% sesquioxides in the unweathered stage, is changed into a sesquioxide rich (= 60%) end product due to the leaching of silicium (–35%) and bases (-14%). This process is known as relative accumulation. However, when sesquioxides have been mobilized, water moving through the weathering zone may transport the sesquioxides. This transportation may either be over large distances (e.g. down slopes) or within the soil profile. During wetting of the soil in the rainy

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season, water and the sesquioxides will move downward in the soil profile, whilst in the drying phase water and sesquioxides may travel upward due to capillary forces, (Morin et al, 1971). The total amount of sesquioxides may in this manner increase in certain places; a process referred to as absolute accumulation. The character of the soil deposit is affected by the extent of concentration of the accumulated hydrated oxides. Thus, the soil may be found existing as unhardened, or as a hardened layer, or as a constituent like concretionary nodules in a soil matrix or a cemented matrix enclosing other materials. Laterite is usually yellow, ochre, red or purple in colour but red appears to be the most common colour; it is also found formed over all types of rocks (igneous, sedimentary, and metamorphic) in Ghana.

1	PARENT ROCK	IGNEOUS AND METAMORPHIC ROCKS ACID → DIRECTION OF DECREASE IN STABILITY → BASIC								
2	**Light minerals**	Quartz	Muscovite	Potash feldspar			Sodic plagioclase		Calcic plagioclase	
3	**Dark minerals**				Biotic	Amphibole		Pyroxene		Olivine

INITIAL WEATHERING UNDER TROPICAL CONDITIONS

4	**Initial weathering Products**	No change but some solution	Vermiculite or Montmorillonite	Slow weathering to Kaolinite or Halloysite	Vermiculite or Montmorillonite	Chlorite calcite or Montmorillonite	Kaolinite or Halloysite	Chlorite calcite or Montmorillonite	Kaolinite or Halloysite	Serpentine or Montmorillonite

CONTINUATION OF WEATHERING UNDER WARM OXIDIZING CONDITIONS

5	**Further weathering Products**	No change but additional solution	Kaolinite and Gibbsite	Kaolinite or Halloysite	Kaolinite and Gibbsite	Kaolinite and Goethite limonite or Haematite	Kaolinite or Halloysite	Kaolinite and Goethite limonite or Haematite	Kaolinite or Halloysite	Kaolinite and Goethite limonite or Haematite

CONCENTRATION OF MINERALS INTO DISCRETE HORIZON BY LEACHING AND RESIDUAL ACCUMULATION OR SOLUTION AND PRECIPITATION

6	*LATERITE*

CONCRETIONARY GROWTH.

Figure 2.3 Summary of process involved in the formation of laterite. (source: Charman, 1995)

Table 2.1 Weathering of Dolerite rock, Guyana. (After Galjaard, 1994)

MINERALS	PARENT ROCK (A)	WEATHERED PRODUCT (B)	DIFFERENCE (A-B)
SiO_2	51.3	16.1	-35.2
Al_2O_3	15.2	29.1	+13.9
$FeO + Fe_2O_3$	14.3	31.9	+17.6
CaO	9.6	0.02	-9.58
MgO	5.6	0.06	-5.54
K_2O	0.6	0.06	-0.54
Na_2O	2.1	0.05	-2.05
H_2O	0.3	20.2	+19.9
SUM	99.0	97.49	-1.51

Brammer and Wills (1962), have indicated that the distribution of soils in Ghana relates very well to the distribution of the parent rocks and the climatic, vegetation, topography and drainage conditions that pertain at the source where the soil had originated.

The availability of iron and aluminium minerals, and / or quartz within the parent rock, for example, will strongly influence the formation of laterite soil. Thus, where quartz is a major component of the parent rock it remains in the weathering product as quartz grains facilitating an end product granular in texture with the laterite forming minerals, kaolinite and the sesquioxides, forming the matrix of the material or forming concretionary products around the quartz nuclei. Parent rocks concentrated with iron and aluminium minerals (eg. basic rocks), on the other hand, will facilitate the development of concretionary products (Charman, 1995; Fookes, 1997).

In continuously wet regions the end-products of the material are likely to be characterised by high moisture contents and high plasticity, whereas in regions subject to distinct wet and dry seasons, the products of laterization are more likely to be characterized by low natural moisture content and low plasticity and the presence of concretions and cemented horizons.

2.4 The Classification of laterite soils

Attempts at finding a more effective classification system capable of grouping the various laterite with much precision for engineering purposes, has not been easy. This has partly been due to, the range of laterite soil types often found, and the fact that the sequence of events necessary for the formation of laterite can begin in all kinds of soils. Some classification systems considered effective, in the classification of the laterite soils of Ghana are hereinafter discussed in brief (see Table 2.2).

Table 2.2 The definition or Characteristics of Ghana Soil

(after D'Hoore, 1964; Morin et al, 1971; Duchaufour, 1982).

Characteristics	Soil Types		
	Ferruginous Soils	**Ferrisols**	**Ferallitic Soils**
Clay mineral	Mostly Kaolinitic	kaolinite amorphous oxides of iron and aluminium.	kaolinite.
SiO_2 / Al_2O_3	Near 2 or slightly higher	Near 2 (mostly slightly below)	Near 2 (but usually below)
SiO_2 /(Fe_2O_3+Al_2O_3)	Always under 2.	-	-
Profile thickness	< 250 cm	Deep	Deeper
Mean annual rainfall mm	600 – 1800	1250 – 2750	1500 – 400
Moisture Region	Semi - arid to moist sub – humid	Moist sub - humid to very humid	Moist humid to humid
Seasons	Wet season with pronounced dry season	Wet season with little or no dry season	Wet season with short period of dry season
Vegetation	Savannah and Woodlands	Forest	Equitorial rain forest
Leaching	Moderate	Intense	Intense
Temperature (^{0}C)	20 – 25	>250	20 – 25
Metallic Ions	Loss of alkalies and alkaline earths. Some loss of silica. Concentration of alumina, ferric ion and titania	Loss of alkalies, alkaline earths and silica. Concentration of aluminium, ferric oxide and titania.	Loss of alkalies, alkaline earths and silica. oncentration of alumina. Ion may be lost or gained under reducing and oxidizing condition.
Mineralogy	Henatite, geothite, and kaolinite. Organic matter absent or sparse.	Gibbsite, goethite with Kaolinite. Organic matter may be abundant.	Predominantly Kaolinite with goethite; hematite and gibsite less common. Organic matter sparse to abundant
pH (mean)	6.3	5.9	4.7

2.4.1 *D' Hoore's classification system*

The D' Hoore's classification system, for example, is a pedological classification system associated with French practice. Morin et al (1971) used this system to group the various soils in Ghana into three main groups as:

1. Ferruginous Soils
2. Ferrisols
3. Ferallitic Soils

The characteristics of these soils have been shown in Table 2.3.

Table 2.3 Relationship between CWI, and weathered rock material (after Sueoka, 1990)

CWI (%)	GRADE	EXTENT OF WEATHERING	CLASSIFICATION OF WEATHERED PRODUCT
3 – 15	I	Fresh rock	
15 – 20	II	Slightly weathered	
	III	Moderately weathered	Fresh rock
	IV	Highly weathered	
20 – 40	V	Completely weathered	Saprolite soil
40 – 60	VI	Residual soils	Lateritic soil
60 – 90		Weathered and hardpan	Laterite or bauxite

The philosophy behind this form of classification has been summarised by Duchaufour (1982) as follows:

(i) Fersiallitization (2:1 clays dominant), (ii) Ferrugization (Kaolinite and 2:1 clays), and (iii) ferallitization (kaolinite and gibbsite), are three types of weathering which do not belong to different cycles but to three phases of the cycle of weathering necessary for the development of residual soil in the tropics, with ferrallitization being the end stage of the process. The 2:1 clays refer to Illite, montmorillonite and chlorite. These have a basic structure of two silica tetrahedron sheets to one alumina octahedral sheet. Note that stage (i) is rarely exceeded in sub tropical climates with a marked dry season; in a dry tropical climate development stops at stage (ii); and it is only in humid equatorial climates that stage (iii) is reached. The increase in the speed of pedogenesis, owing to rise of temperature on the one hand and increase of precipitation on the

other is fundamental to the final equilibrium stage that is reached. The three phases are characterized by increasing weathering of primary minerals, increasing loss of silica and increasing dominance of new clay minerals formed from dissolved materials. Ferrisols, however, exist as a transitional stage between the ferruginous and ferrallitic soils.

2.4.2 *The Silica to Sesquioxide Ratios Classification System*

Laterite soils have also been classified using the silica: sesquioxide ratio (Morin et al, 1971). This ratio has been used to measure the extent to which a residual soil had been laterized. The silica (SiO_2) content here is that remaining dissolved in the soil, whereas, the sesquioxides are simply the amount of Fe_2O_3 and Al_2O_3, which had accumulated in the soil. It is expressed as follows:

$$\frac{SiO_2}{R_2O_3} = \frac{SiO_2}{Fe_2O_3 + Al_2O_3}$$

True laterites have been classified as having ratios less than 1.33, but the ratios for lateritic soils are considered as between 1.33 and 2.00. Non-lateritic soils, on the other hand, have their ratios being greater than 2.00. The test has rather been unpopular since it involves a chemical analysis that is not readily available to the practicing engineer. Besides, experience has indicated that the ratio is by no means a unique indicator of the index properties or engineering characteristics required by the engineer. Thus many other factors are of greater importance.

2.4.3 *The Chemical Weathering Index*

It is also possible to use the chemical weathering index (CWI) suggested by Sueoka, 1990, for the classification of laterite soils as shown in Table 2.4. CWI is defined as follows:

$$CWI = \frac{Al_2O_3 + Fe_2O_3 + TiO_2 + H_2O^{(\pm)} \text{ mole} \times 100\ (\%)}{\text{(All chemical component)}}$$

Thus CWI (%) values greater than 60 are indications of laterite soils whilst that between, 40 – 60 represent lateritic soils.

Table 2.4 Recommended classification system for laterite (after Charman,1995)

AGE	Recommended name	CHARACTERISTIC
Immature (young)	Plinthite	Soil fabric containing significant amount of laterite material. Hydrated oxides present at the expense of some soil material. Unhardened, no nodules present, but there may be slight evidence of concretionary development.
	Nodular Laterite	Distinct hard concretionary nodules present as separated` particles.
	Honeycomb Laterite	Concretions have coalesced to form a porous structure which may be filled with soil material.
	Hardpan Laterite	Indurated laterite layer, massive and tough.
Mature (old)	Secondary Laterite	May be nodular, honeycomb or hardpan, but is the result of erosion of pre-existing layer and may display brecciated appearance.

2.4.4 *TRRL Classification system for Laterite*

A recent work by Charman, 1995; has suggested the classification system detailed in Table 2.4. The system classifies laterite soils into plinthite, nodular laterite, honeycomb laterite, hardpan laterite, and secondary laterite. In road pavement, the laterite material largely used is expected to be gravely in texture. For this reason usage is often made of nodular laterites. The system further defines the quartz gravel present in nodular laterite containing quartz into various classes since their quantity tends to influence the performance of the nodular material in road pavements.

2.5 Rainfall and Topography

The process of chemical weathering is known to be influenced by climate. Temperature in Ghana lacks any significant variation from one part of the country to another. Thus, any differences in the chemical weathering process, which might occur within the various localities are possibly influenced more by changes in rainfall intensity than by temperature. A typical trend of the average annual rainfall pattern for Ghana spanning the period from 1961-1990 has been shown in Table 2.5. Rainfall intensity apart from promoting some of the chemical reactions that take place during chemical weathering, also aids in the leaching of both soluble and insoluble minerals and the lessivage of clay minerals.

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Topography on the other hand controls the rate of weathering by determining the amount of water that moves through the weathering zone. The percentage of rainfall, which is diverted as run – off, depends largely on the slope of the ground surface. Generally, Ghana is not a mountainous country. Its relief is of subdued topography, consisting of flat areas and gently undulating or elevated plateaus, which allows for deep profile development since erosion is not great in most parts of the country, (Morin and Ayetey, 1971). For example, whereas, on the summits and upper slopes aluminium salts are concentrated, iron salts are concentrated in the middle slopes while magnesium and calcium are concentrated in the lower slope profiles. Thus, variations in the drainage conditions at the various parts of the topography cause the colour of the soils to change from red to brown at the summit or upper slopes, brown to yellow in the middle slope, and grey in the lower slope, (Brammer, 1962).

2.6 Weathered Rock Materials

Where the overburden soil material is reasonably small in thickness it is excavated together with the underlying rock fragments which have largely suffered only the physical stage of weathering, for construction of pavement layers. It must be noted here that such class of material had very often formed good base materials on some roads in Ghana.

2.7 Zoning of the Country

With some approximation, it is possible to group the various regions of the country into three agro-ecological zones as illustrated in Figure 2.4, based on the average rainfall data for Ghana shown in Table 2.5. This is also the zoning being used by G.H.A. The fundamental assumption made is that at the various rainfall intensities, the occurring natural soils are likely to exhibit some basic engineering characteristics peculiar to their zones. The zoning has been based on administration boundaries for convenience of identification. The zones are made up as follows:

Zone 1: The Northern, Upper East and Upper West regions.

Zone 2: The Brong-Ahafo, Ashanti, Eastern and Western regions.

Zone 3: The Central, Greater Accra, and Volta regions.

Besides the annual average rainfall intensities, Table 2.5 depicts in brief the prevailing topography and the main parent rocks found in the said three zones.

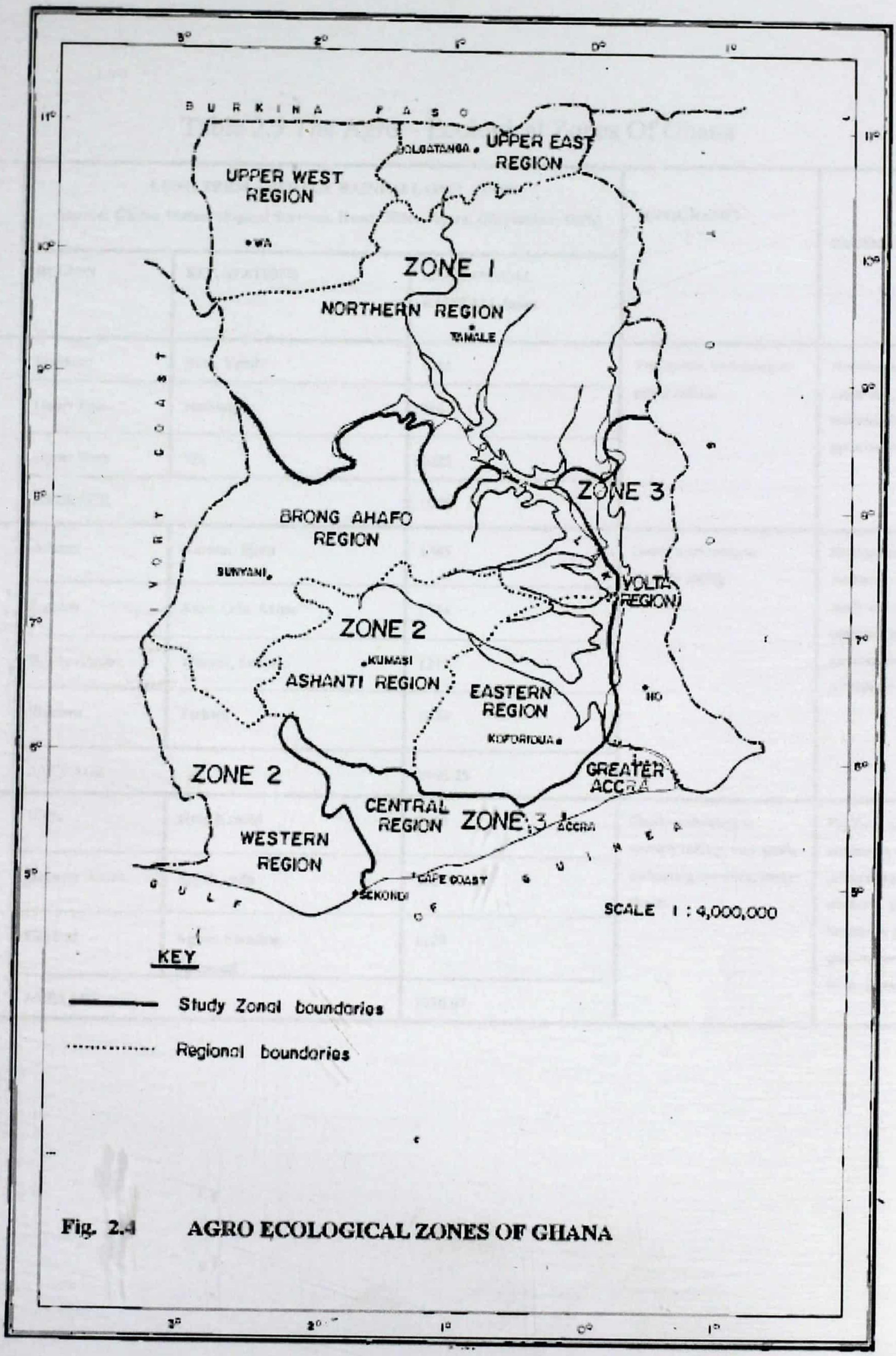

Fig. 2.4 AGRO ECOLOGICAL ZONES OF GHANA

Figure 2.4 AGRO ECOLOGICAL ZONES OF GHANA

Table 2.5 The Agro – Ecological Zones Of Ghana

ZONE	LONG TERM AVERAGE RAINFALL (1961 – 1990) Source: Ghana Meteorological Services, Head Office, Accra. (November, 1996).			TOPOGRAPHY	PARENT ROCK
	REGION	**REP. STATIONS**	MEAN ANNUAL **RAINFALL (mm)**		
1	Northern	Bole, Yendi	1165	Very gentle, undulating to gently rolling.	Phyllites, schists, granites, sandstone, shale, mudstone, metamorphosed lavas, pyroclastic rocks.
	Upper East	Navrongo	986		
	Upper West	Wa	1023		
	AVERAGE		1058		
2	Ashanti	Kumasi, Ejura	1385	Gently undulating to strongly rolling.	Phyllites, schists, granites, sandstone, shale, mudstone, sandy and pebbly beds, quarzites, conglomerate, metamorphosed lavas, pyroclastic rocks.
	Eastern	Akim Oda, Akuse	1314		
	Brong Ahafo	Wenchi, Sunyani	1212		
	Western	Tarkwa	1874		
	AVERAGE		1446.25		
3	Volta	**Kete Krachi**	1143	Gently undulating to strongly rolling; very gentle undulating to rolling; steep slopes.	Phyllites, schists, granites, sandstone, shale, mudstone, sandy and pebbly beds, quarzites, gonglomerate, limestone, gneiss, arkose, graywackes metamorphosed lavas, pyroclastic rocks.
	Greater Accra	**Accra, Ada**	838		
	Central	**Agona Swedru, Saltpond**	1129		
	AVERAGE		1036.67		

3. REVIEW OF COMPACTION

3.1 Soil Compaction

Soil compaction is defined as the process of bringing about an increase in soil density with a corresponding reduction of the volume of air void but without any change in the volume of water. It is usually effected by such mechanical means as rolling, tamping or vibrating of the soil. It is the most efficient and widely used method available today for improving the engineering properties of a soil meant for construction purposes, such as reducing void ratio and permeability, increasing shear strength and bearing capacity, reducing compressibility and thus making the soil less susceptible to volume changes and settlement under the influence of vibration.

3.1.1 *Dry density / moisture content relationship for cohesive soils.*

The state of compaction of a soil is measured in terms of its dry density. For a loose dry soil the dry density gained under an applied load is low. However, as we gradually add water to this dry soil, films of absorbed water form around the soil particles. As more water is added, it causes the absorbed water films to increase in thickness. This new state of the absorbed water films serving as lubricant, makes the soil workable, and thus enables the soil particles to become more closely packed together. The end result is that the density of the soil mass increases with increasing water content till it reaches a maximum value. Beyond this, with any further increase in the water content of the soil, the absorbed water films cease to act as lubricant but rather begin to push the soil particles apart and cause the soils density to decrease.

Standard laboratory compaction tests give relationships of the type shown in Figure 3.1. This curve shows that for a particular compactive effort increasing moisture contents yield increasing densities up to an optimum moisture content, but beyond this point the addition of further water leads to lower densities. The laboratory dry density-moisture content curve for a particular compactive effort must lie completely to the left of the zero air void line or the 100% saturation line, as shown in Figure 3.1. This line defines the theoretical maximum dry density, which corresponds to the condition when all the air in the soil has been expelled during the compaction process, for a given moisture content. However, in practice this state of

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compaction is unachievable. The figure also shows that with increasing compactive effort, dry densities increase, with corresponding decrease in optimum moisture content.

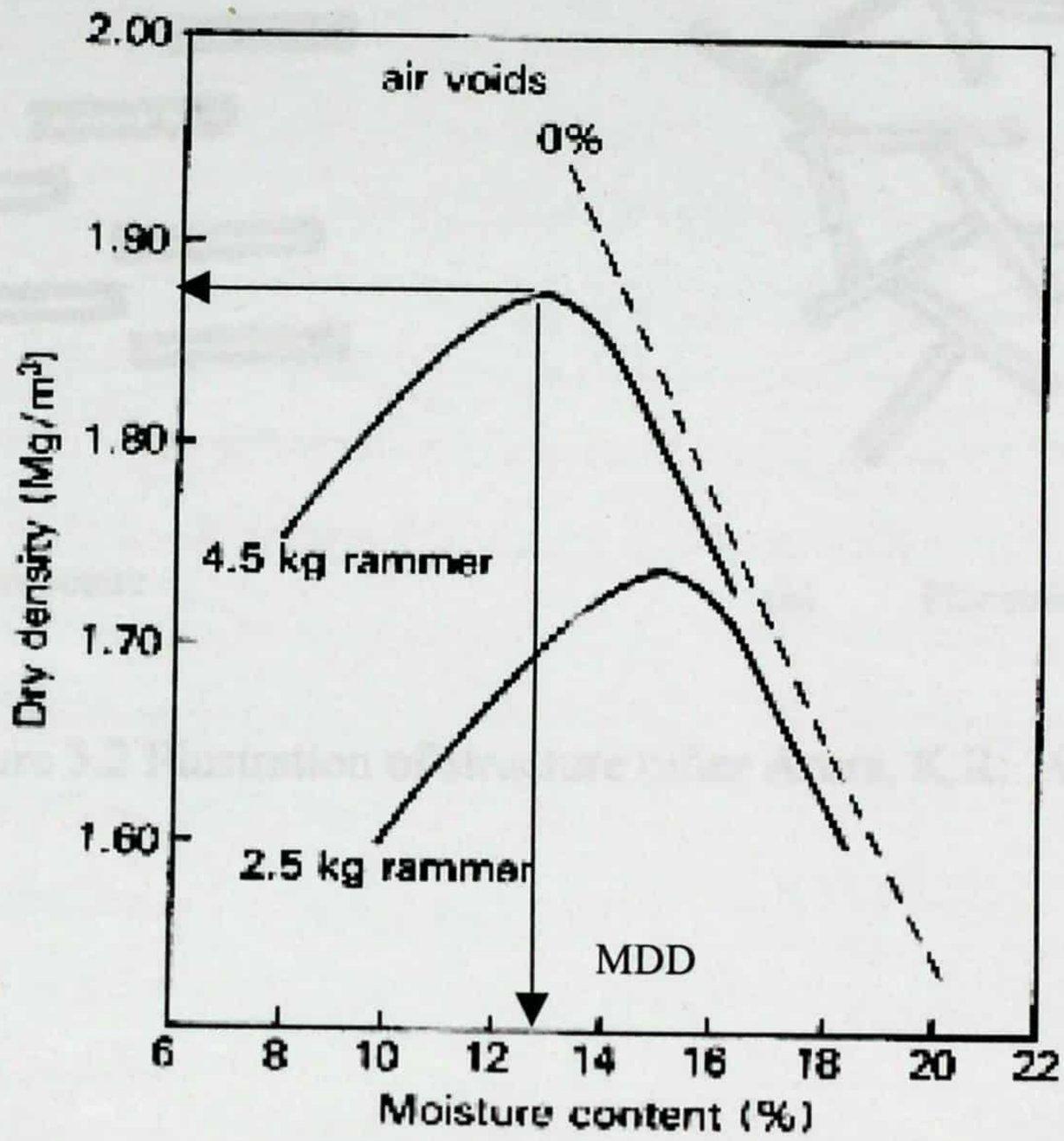
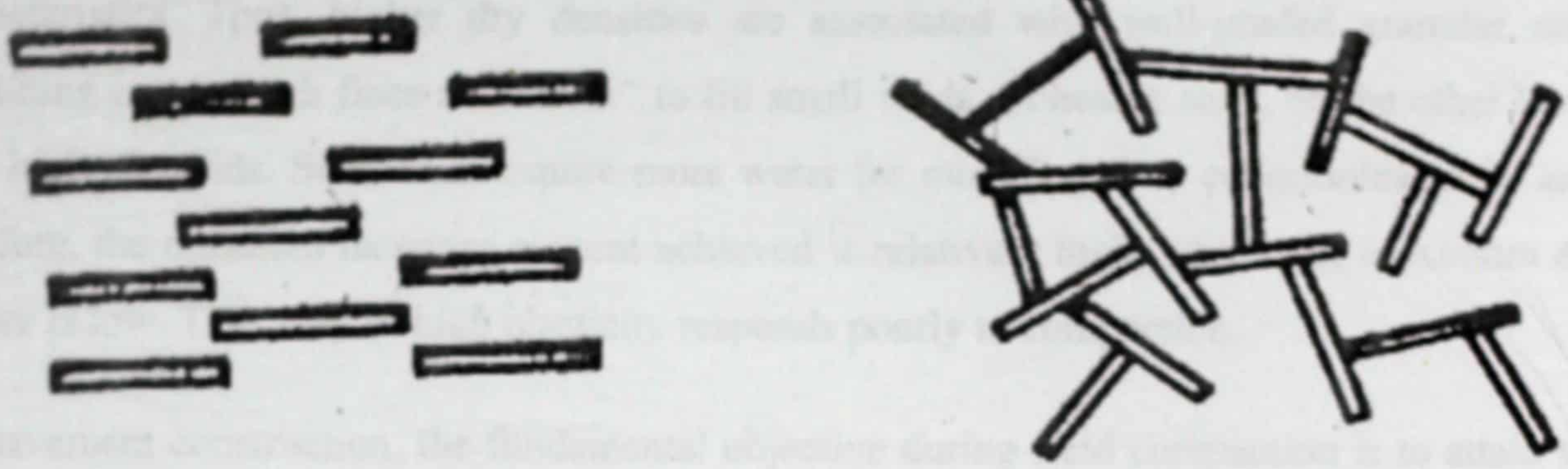


Figure 3.1 Effect of compactive effort on dry density & moisture content

The compacted soil structure

The structure of a compacted soil is different for different moulding moisture contents, see Figure 3.2). Whereas the structure at moisture content dry of the optimum may be described as flocculated, that on the wet side of the optimum may be described as dispersed. Flocculated structured soils are induced by low shear strains, and they exhibit low compressibility, high permeability and high shear strength. By comparison, a dispersed structure, which is induced by large shear strain is flexible and therefore, has high compressibility, shear strength, and low permeability. Thus a careful manipulation of the moulding water content can yield material of required property.



(a) Dispersed structure (b) Flocculated structure

Figure 3.2 Illustration of structure (after Arora, K.R: 1997)

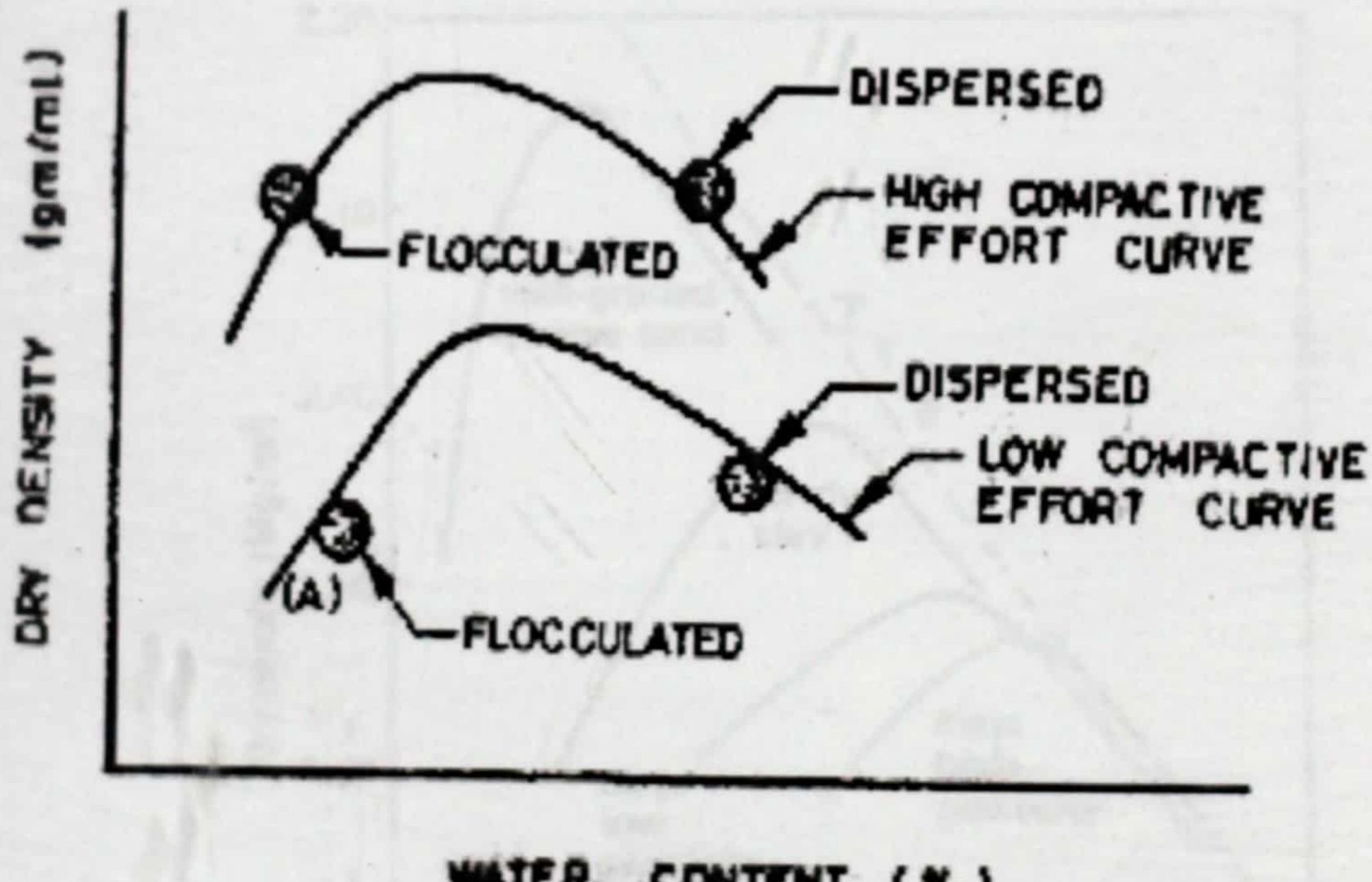


Figure 3.3 Soil Structure in Compacted Soils (after Arora, K.R: 1997)

3.1.2 *The effect of type of soil*

For a given compactive effort, the maximum dry density and optimum moisture content achieved is primarily dependant on the type of soil. This has been shown in Figure 3.4.

Ideally, a soil with a gradation allowing for a minimum of voids is best for compaction. For example, Figure 3.5, depicts three possible physical states of soil-aggregate mixtures and their characteristics. Thus, higher dry densities are associated with well-graded granular soils containing just enough fines as "binder" to fill small voids. Cohesive soils, on the other hand, have high air voids. Such soils require more water for moulding than cohesionless soils and, therefore, the optimum moisture content achieved is relatively high, whiles the maximum dry density is low. Thus clay of high plasticity responds poorly to compaction.

For pavement construction, the fundamental objective during field compaction is to attain the maximum dry density obtained in the laboratory. This is assessed, by comparing the dry density achieved in the field after compaction to the maximum dry density obtained in the laboratory. Thus, the required level of compaction may be specified in terms of the relative compaction, as a percentage. In Ghana, the specification of MRH allows a certain margin of error, and hence accepts 98% for base course and 96% for sub-base. These margins again define the moisture range over which it is possible to achieve the specified level of compaction in the field.

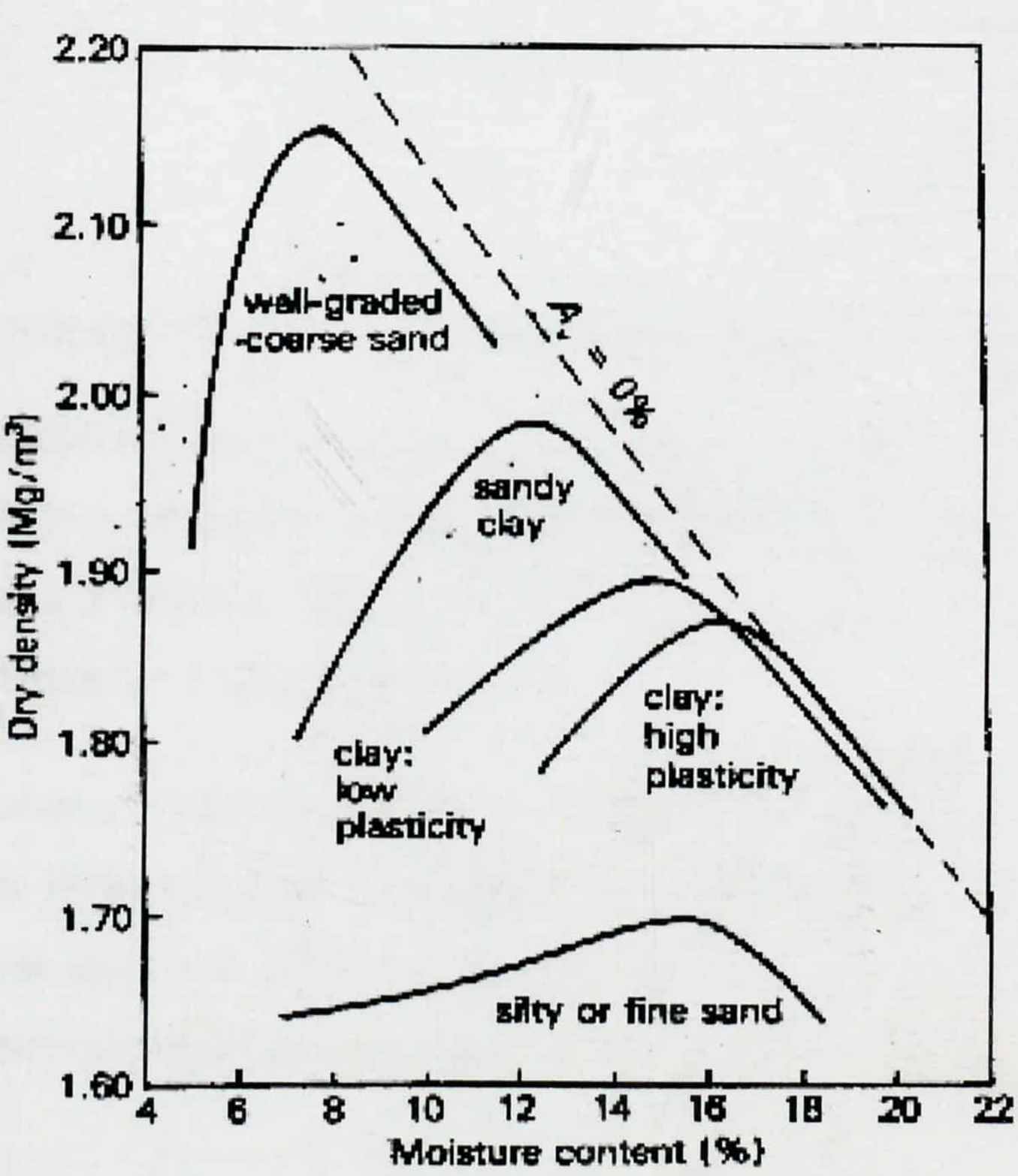
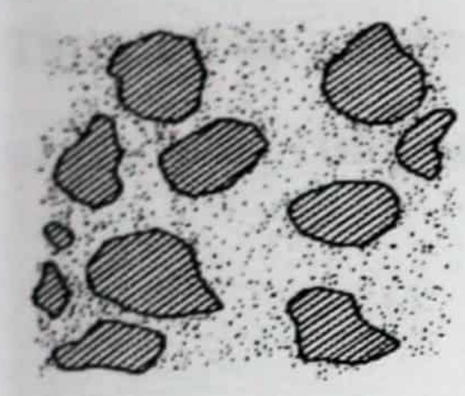
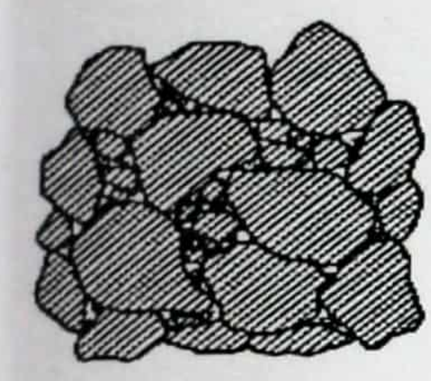


Figure 3.4 Influence of soil types on compaction (after Whitlow, R; 1992)



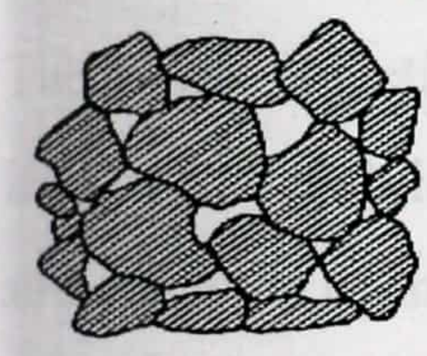
A (Skeleton of fines matrix)

- Large fine content
- No grain to grain contac
- Not difficult to compact



B (Skeleton with sufficient fines)

- Sufficient fines
- Grain to grain contact
- Moderately difficult to compact



C (Skeleton without fines)

- No Fines
- Grain to grain contact
- Very difficult to compact

Figure 3.5 Three possible states of natural soils for road construction (after Yonder, 1957)

More generally, the level of compaction of a soil achieved increases with a decrease in the thickness of the layer. For economic reasons, the thickness is rarely kept less than 15cm. Thus, it is a common practice in Ghana to find loose lifts of 15cm to 30cm in the field, depending on the designed specification for the layered thickness.

Similarly, with increasing number of passes, for a particular compaction plant, the level of compaction increases. However, there is an upper limit beyond which, any further increase in the number of passes does not result in appreciable increase in density. Thus, effective compaction is often considered achievable within the limits of 3 to 12 passes for most plants.

3.1.3 *Mechanisms for Soil Compaction*

The various mechanisms by which compaction equipment or plants achieve densification of soils during compaction may be listed as follows:

(1) static pressure only.

(2) impact / dynamic pressure.

(3) static pressure and vibration.

(4) static pressure and kneading action.

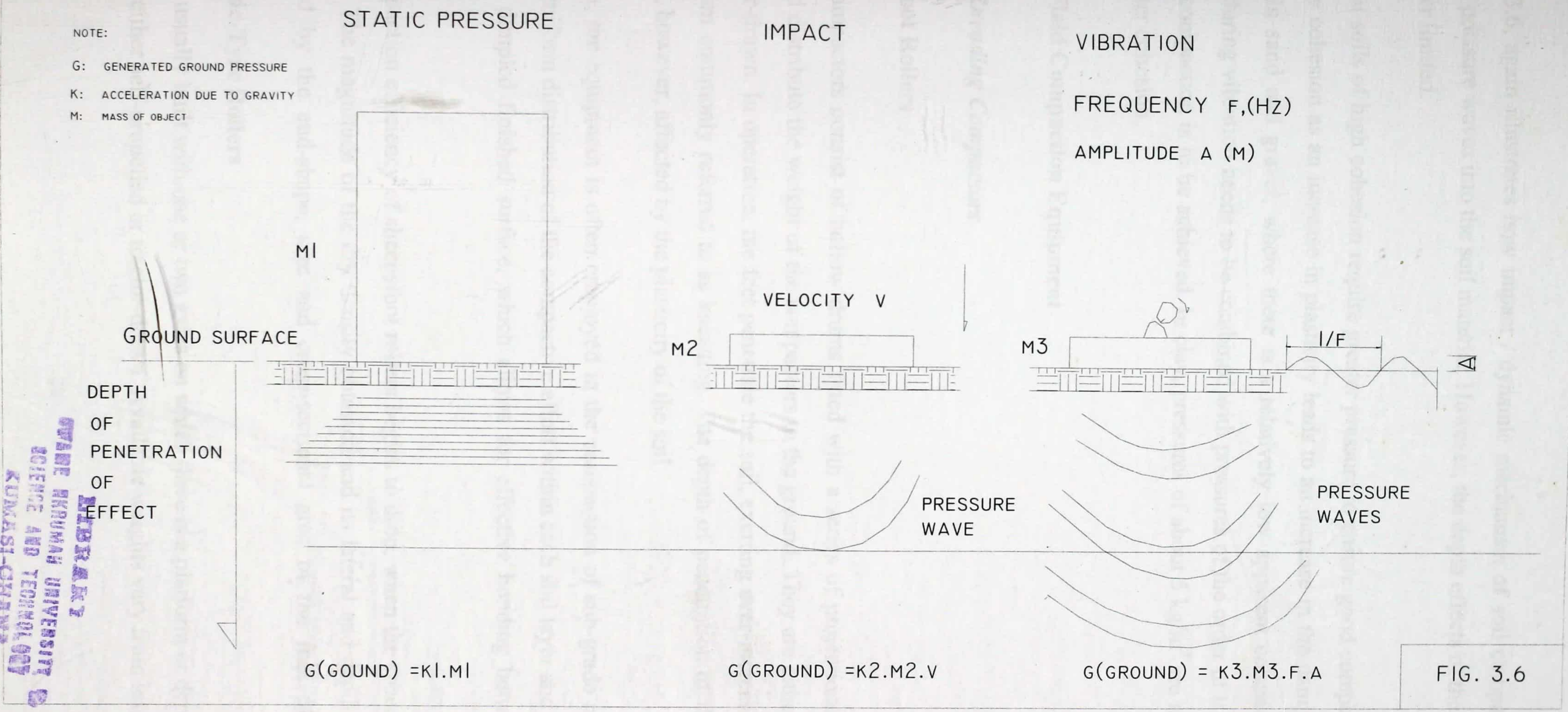
(5) static pressure, kneading action and vibration.

Static pressure, impact, and, static pressure and vibration principles of compaction have been illustrated in Figure 3.6.

The main objective of compaction is to re-pack the soil particles into a dense material. However, the ability to re-pack under an applied effort is influenced by the inter-particle forces and cohesion of the soil material. Thus for the same soil and layer thickness, one mechanism of effecting compaction may yield a better re-packing effect than the other.

As illustrated in Figure 3.6, static pressure has a limited depth effect in terms of compaction, because an increase in static pressure causes an increase in the inter-particle frictional forces. The phenomena consequently prevent the interlocking of the soil particles into a dense component. A combination of static pressure and vibration, on the other hand, work with a rapid succession of impact against the surface of the soil material. Thus from the surface, pressure waves are sent down through the soil. The soil particles are, as a result, set in motion, whiles the internal friction between the particles is virtually eliminated. In their state of motion the particles assume such new positions, with the smaller grains filling in the spaces between the bigger grains, such that a denser volume of material having a lower void ratio is obtained. When water is introduced in the process, it facilitates the movement of the soil particles by acting as a lubricant as well as a conductor for the vibration

DIFFERENT PRINCIPLES FOR SOIL COMPACTION



(AFTER FORSSBALD, 1965)

Figure 3.6 Different Principles for soil compaction (After Forssbald, 1965)

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Figure 3.6, again illustrates how impact / dynamic mechanism of soil compaction works by sending pressure waves into the soil material. However, the depth effects of the pressure waves are rather limited.

Note that soils of high cohesion require greater pressure to ensure good compaction than soils with low cohesion as an increase in plasticity leads to an increase in the damping of pressure waves. In sand and gravel, where there is a relatively low apparent cohesion, the state of motion during vibration needs to be combined with pressures of the order of 0.5 – 1.0 kg /cm^2 if good compaction is to be achieved. In clay, pressures of about 5 kg/m^2 are necessary due to the greater cohesion.

3.2 Field Compaction Equipment

3.2.1 *Kneading Compactors*

Sheepsfoot Rollers

These compactors consist of hollow drums fitted with a series of projections or feet, which carry and distribute the weight of the compactors to the ground. They are either self-propelled or tractor-drawn. In operation, the feet penetrate the soil, exerting ever-increasing pressures, a mechanism commonly referred to as kneading. The depth of penetration of the feet of these rollers is, however, affected by the plasticity of the soil.

In Ghana, the equipment is often employed in the compaction of sub-grade material since it ensures uniform distribution of the compactive effort within each soil layer and also imparts an irregular dimpled finished surface, which allows for effective bonding between successive layers.

The compaction efficiency of sheepsfoot rollers begins to drop, when the speed exceeds 10 to 15 km/h. The magnitude of the dry density obtained and its lateral and depth effect are also influenced by the end-shape, size and cross-sectional area of the foot of these rollers.

Pneumatic-Tyre Rollers

They are usually built with one or two axles on which there is a platform or deposit for ballast. They are either self-propelled or tractor-drawn. Available weights vary from less than 13tonnes

to 110tonnes. The roller is also fitted with an oscillating isostatic wheel suspension, which enables it to ensure equal loading on each tyre or wheel when even compacting over an uneven terrain. The compactive effort, consisting largely of static load, (see Figure 3.7), is exerted on an area of elliptical tyre "foot print".

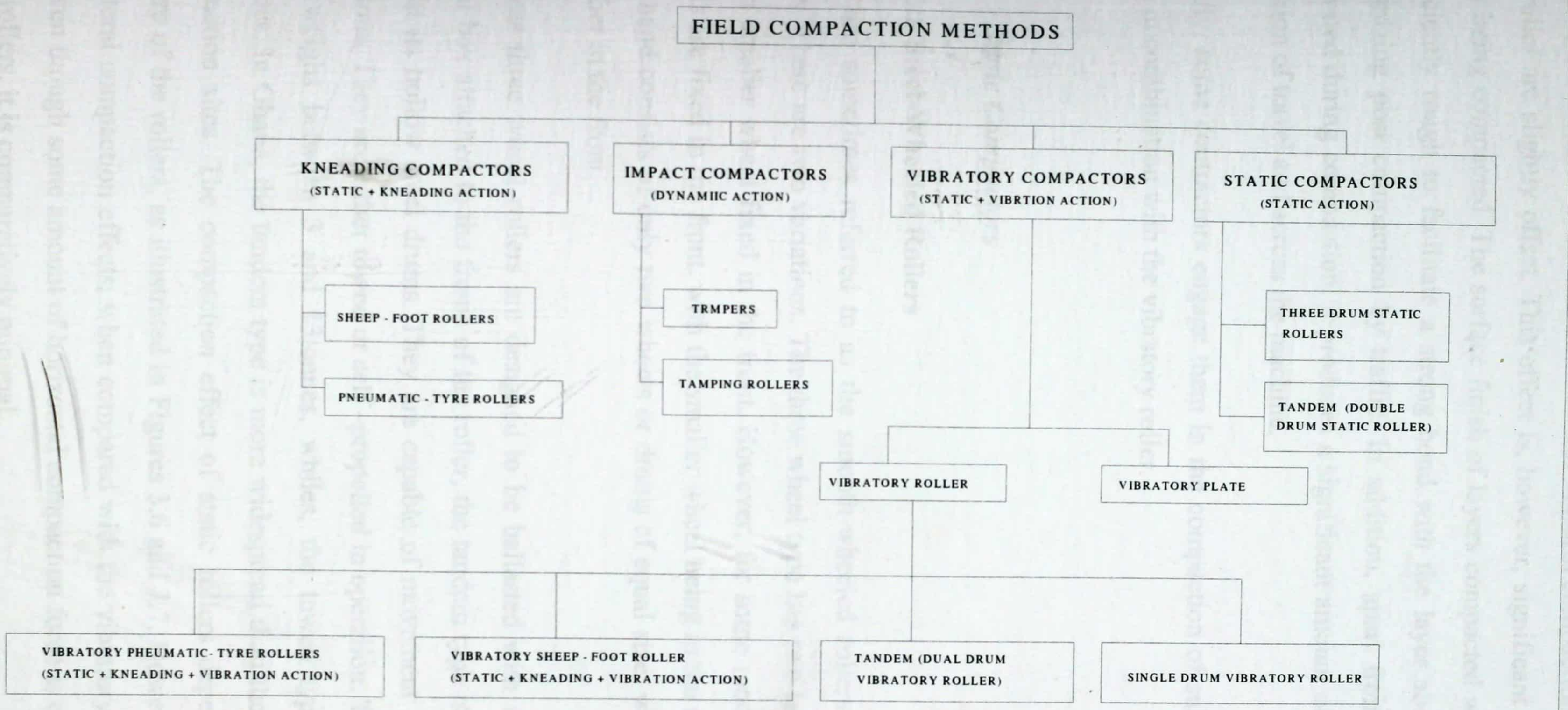

FIG. 3.7 MODES OF EFFECTING COMPACTION IN THE FIELD

Figure 3.7 Modes of Effecting Compaction in the Field

The tyre tread and the tyre flexing produces some knead which causes large angular deformations and effective densification. For uniform compaction, the front and rear wheels of the roller are slightly offset. This effect is, however, significant in the uppermost part of the layer being compacted. The surface finish of layers compacted with pneumatic-tired rollers is sufficiently rough to facilitate a strong bond with the layer above. It has the advantage of minimizing post compaction by traffic. In addition, apart from the normal vertical forces generated during compaction, it produces a significant amount of horizontal force in both the direction of travel and across the machine.

Locally, some contractors engage them in the compaction of sub-base and base layer works often in combination with the vibratory roller.

3.2.2 *Static Compactors*

Smooth Steel-Wheeled Rollers

They are sometimes referred to as the smooth-wheeled rollers or the smooth steel wheel rollers. There are two variations. The three wheel type has two larger wheels fixed in the rear with a smaller wheel fixed in the front. However, for some modern versions, the two larger wheels are fixed in the front, with the smaller wheel being in the rear. The tandem type on the other hand consists of only two wheels or drums of equal size; with one drum in the rear and the other in the front.

Whereas three wheel rollers are designed to be ballasted with water or wet sand kept in a special box attached to the frame of the roller, the tandem type is ballasted with water or wet sand in its hollow steel drums. They are capable of movement in the backward or forward directions. They are either towed or self –propelled in operation. The self-propelled type, most often weighs between 3 and 13tonnes, whiles, the towed type weighs between 14 and 20tonnes. In Ghana, the tandem type is more widespread than the three wheeled type at most construction sites. The compaction effect of static rollers depends mainly on the vertical pressure of the rollers, as illustrated in Figures 3.6 and 3.7. However, they have limited depth and lateral compaction effects, when compared with the vibratory rollers, as shown in Figure 3.8. Even though some amount of horizontal compaction force is exerted in the drive direction of the rollers, it is comparatively minimal.

The efficiency of steel wheel roller drops at speeds exceeding 15 km/h. They also have the tendency of bridging over certain portions of the material being compacted and this gives rise to voids and non-uniform compaction.

3.2.3 *Vibratory Compactors*

They are available as vibrating drums, vibrating pneumatic-tyred and vibrating plate equipment (see Figure 3.8). The vibrating drums and pneumatic-tyred types operate either towed or self-driven.

Vibrating Drum

The vibrating drum is more commonly referred to as the vibratory roller. It consists of a frame, isolated from the drum(s) by means of rubber elements. The drum or drums may be designed smooth or sheepsfooted. The static weight of these compactors is composed of the frame mass and drum mass. They are often designed dual-drum or single-drum axle driven. The drum-driven types, provides added traction in loose soils of thick layers, thereby facilitating efficient maneuver. The single-drum axle driven type, is rubber-tyred in the rear, thus making their maneuvers between site sections faster and easier. The high efficiency of the vibratory roller in comparism to the static roller, for example, in the compaction of rocks is shown in Figure 3.9.

Vibrating plate

These consist of either a single or a number of small bottom plates with each plate fitted with a separate vibrating unit. With the aid of vibrational motion, the machine is self-propelled. The machine may move in a forward direction only or be capable of traversing in both forward and reverse motion. They are largely used for small-scale work and to supplement the works of larger machines.

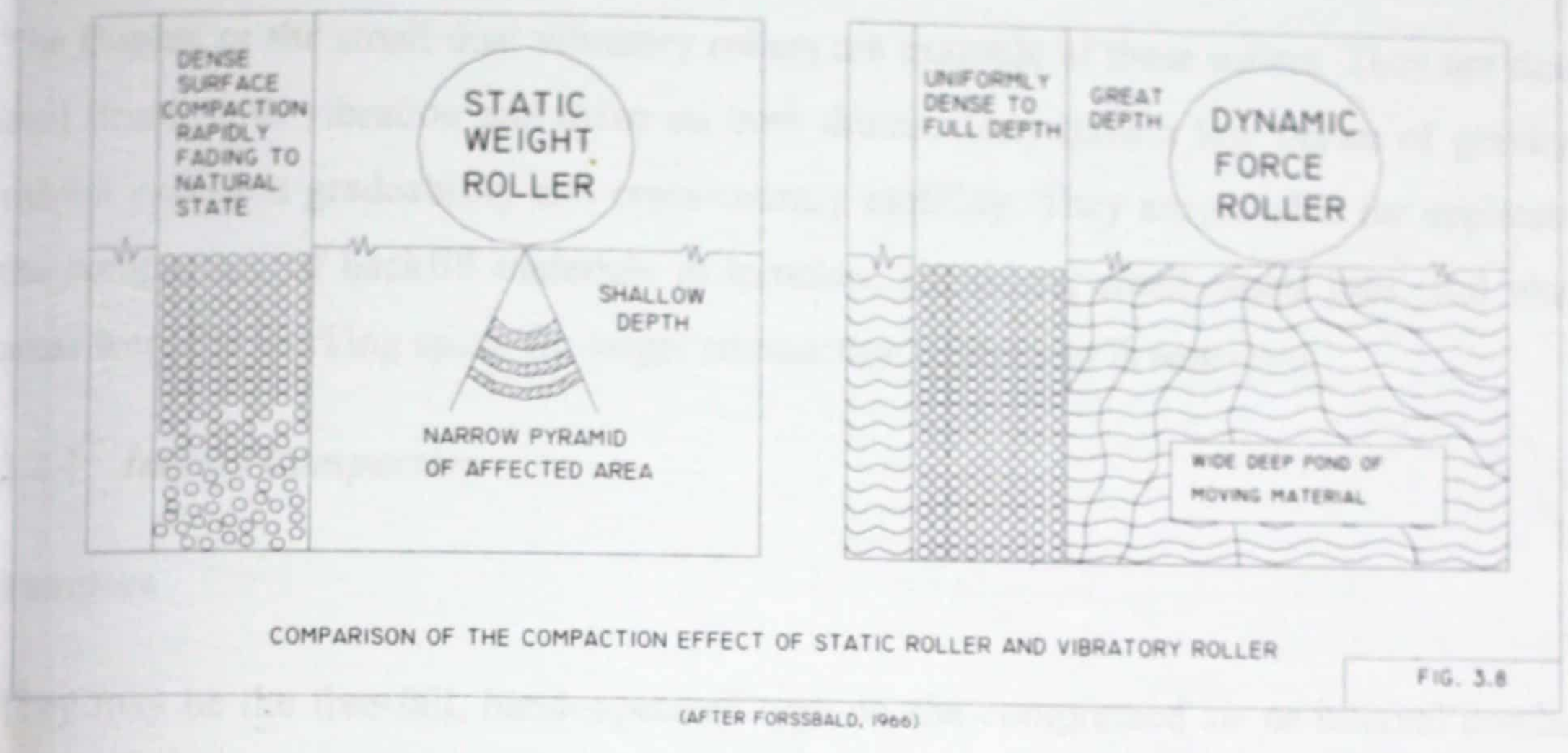

Figure 3.8 Comparison of the Compaction Effect of Static Roller and Vibratory Roller (After Forssbald, 1966)

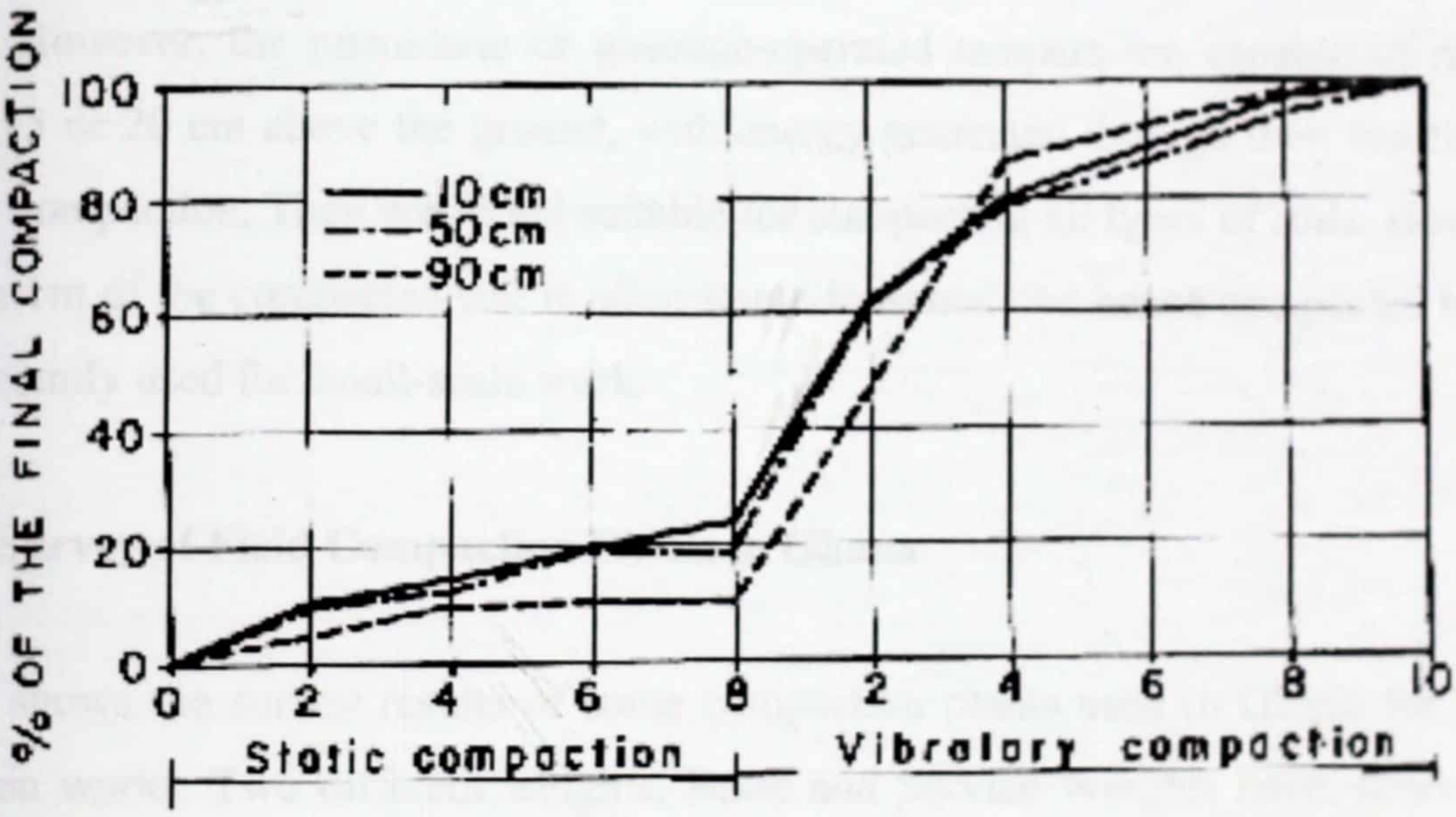

Figure 3.9 Illustration of the efficiency of vibratory compaction

Pneumatic- tyred vibratory compactors

They are designed with a separate vibrating unit attached to the wheel axle. The machine's ballast box is also suspended separately from the axle so that it does not vibrate. Technically, static weight and the dynamic effect of vibration are reinforced by the kneading effect of the roller to make it a very effective equipment in soil compaction.

Hand-only Guiding Vibratory Rollers

The Duplex or the small dual vibratory rollers are example of these rollers. They are designed dual drum, with vibration and drive on both drums. They have a low centre of gravity, and exhibit excellent gradeability and cross-country mobility. They are suitable for application in the compaction of backfill materials in trenches, shoulders, small repair jobs, and works in areas were the working space for larger compaction equipment is restricted.

3.2.4 *Impact Compactors*

Tampers

They may be the free-fall, hand–operated type or, the compressed air or internal combustion driven type. The Free-fall tampers include the handle fitted hammers operated by one man, and the 2 or 3tonnes hammers raised by cables and allowed to fall from a height of about one or two metres. Weights of 10tonnes, with end areas of 2 to 4m^2, and dropped 15m are also available. However, the pneumatic or gasoline-operated tampers are capable of rising to a height of 15 or 20 cm above the ground, with energy generated through their reaction on the soil under compaction. They are found suitable for compacting all types of soils. However, the uppermost 1m of the compacted soil is often found loosened and hence compacted by rolling. They are mainly used for small-scale work.

3.3 A Survey of Field Compaction Plants in Ghana

Table 3.1 shows the survey results of some compaction plants used in Ghana for pavement construction works. Two different weights, Basic and Service Weights have, however, been shown in the said table. Whereas, the term Basic Weight means the dead or shipping weight of the plant, the term Service Weight refers to the maximum ballast weight at which the plant can safely be operated. In summary, the survey reveals that, un-ballasted weights range from 8,238kg to 19,000kg, whiles the ballasted weights range from 9,300kg to 35,000kg for the heavy compaction plants. Photos 1-3 represent some of the field compaction plants captured during the survey of field compaction plants in Ghana.

Table 3.1 Compaction Plants surveyed at some project sites in Ghana.

Contractor	Project site	Plant Type	Weight	
			Basic Weight Dead (kg)	Service / Operational (kg)
A	JZ-Y	Ham Roller -VR	10,800	11,400
		Bomag -VR	10,540	10,779
		Bomag (dual drum) - VR	1,240	1,300
		Bomag (520 mm Plate Type)	-	428
		Bomag (660 mm Plate Type)	-	445
B	GR	Bomag (BW 216 D-2) –VR	15,380	17,650
		DC-12 (Aveling Barford) –SR	8,559	11,911
		Dynapac LP 650H	-	825
C	T– G	Bomag (BW 216 D-2) - VR	15,380	15,380
		Benford SP 2012 - VR	12,030	12,280
D	A-N	Cat. CS 583C – VR	15,040	15,250
		Ingersoll-Rand (SD-100/150)	-	17,200
		Ham HD 85	8,500	9,300
		Ingersoll-Rand (SD-150)	-	19,000
		Ham GRW 18 (Pnuematic tyred)	13,789	14,515
		Cat. (PS-500)	19,000	(27,987 max)
		Dynapac LP 650H	-	35,000
				825
E	AJ–AD	Shaingai Vibratory roller	-	14,500
F	H–D	Bomag (BW 216 D-2) –VR	15,380	17,650
G	K-W	Bomag (BW 216 D-2) –VR	15,380	17,650
H	K–A	Bomag (BW 216 D-2) –VR	15,380	17,650
I	K-RP	Bomag BW 16R	8,238	20,598
		Bomag BW 164AD	9,278	10,393
		Bomag BW 75 ADL	1,377	1,450
J	T–K	Ingersoll-Rand (SD-100)	-	17,200
		Dynapac CA 25	-	9,300

Photo 1 Field Compaction plant in Ghana

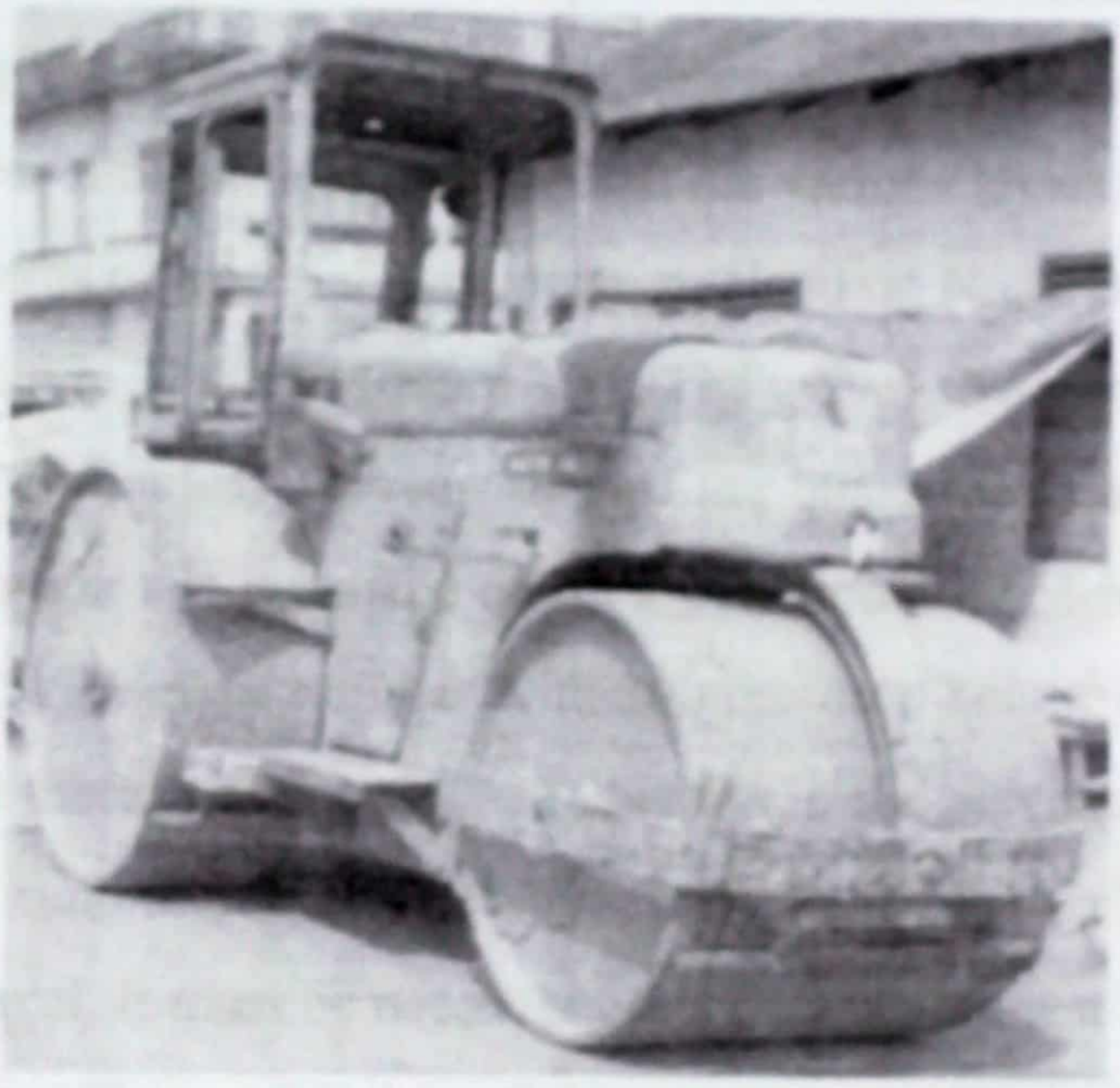

Photo 2 Field Compaction Plant in Ghana

Photo 3 Field Compaction in Ghana

3.4 Effect of Compaction on Particle Size Distribution

The effect of both field and laboratory compaction on particle breakage of the natural gravel materials which had been used for the construction of the base layer, sub-base layer and shoulder was studied on a 50 km long highway constructed in Botswana, by Sandford et al (1980). The test results show that the levels of particle degradation after compaction varied between the ranged between 29% and 80% depending on the type of soil.

Gidigasu and Dogbey (1980) also used a similar approach in reporting on the particle breakage observed during their laboratory and field compaction studies on some lateritic and quartzitic gravels of Ghana. Using the West Africa compaction rammer, the number of blows per layer was increased, and the level of particle breakages at the various levels of compaction achieved was then measured in terms of material percentage retained on No. 7 B.S sieve for the two soil materials as shown in Figure 3.10 and Figure 3.11. The gravel size particles of lateritic gravels are largely concretionary nodules, whereas, that of the quartzitic laterites are largely quartz. The West Africa compaction test is carried out in a CBR mould, in which for a set of five soil layers, 25 blows of a 4.5kg weight rammer with 300mm drop height is applied to each layer. The results indicate that there is about a 10% reduction in the percentage of material retained on the No 7 sieve as the number of blows per layer increases from 0 to 100 for quartzitic gravel and 16% for lateritic gravel. It must be noted that this compaction test method is considered to simulate the compaction effects of lighter field compactors. Thus, the results suggest that larger particle breakages of coarse aggregates are likely to occur under heavy compactors. For example, Figure 3.12 indicates that field compaction can cause particle breakage in some naturally occurring soils in Ghana.

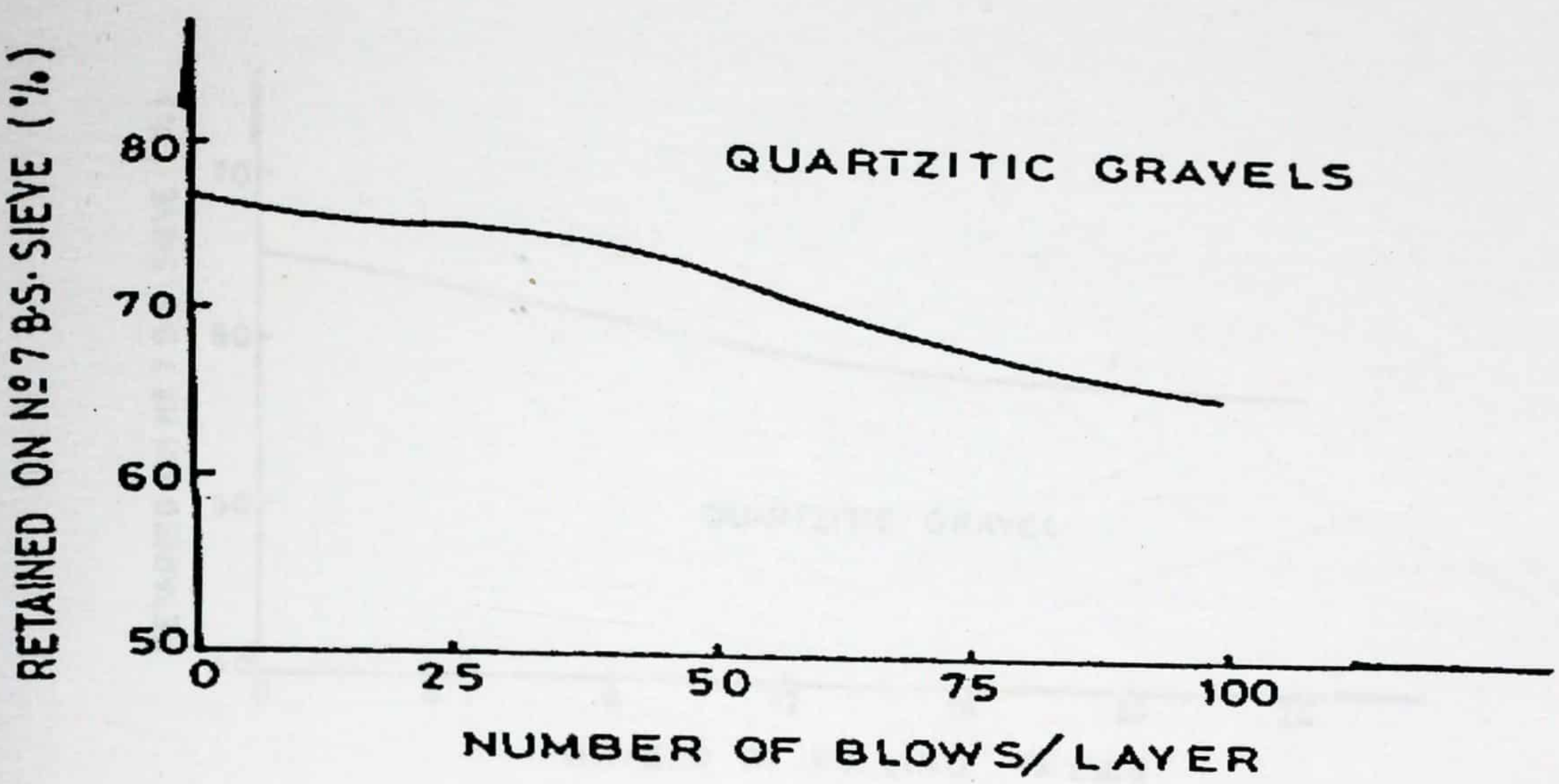

Figure 3.10 Effect of compactive effort on particle breakages in quarzitic gravels (after Gidigasu and Dogdey, 1980)

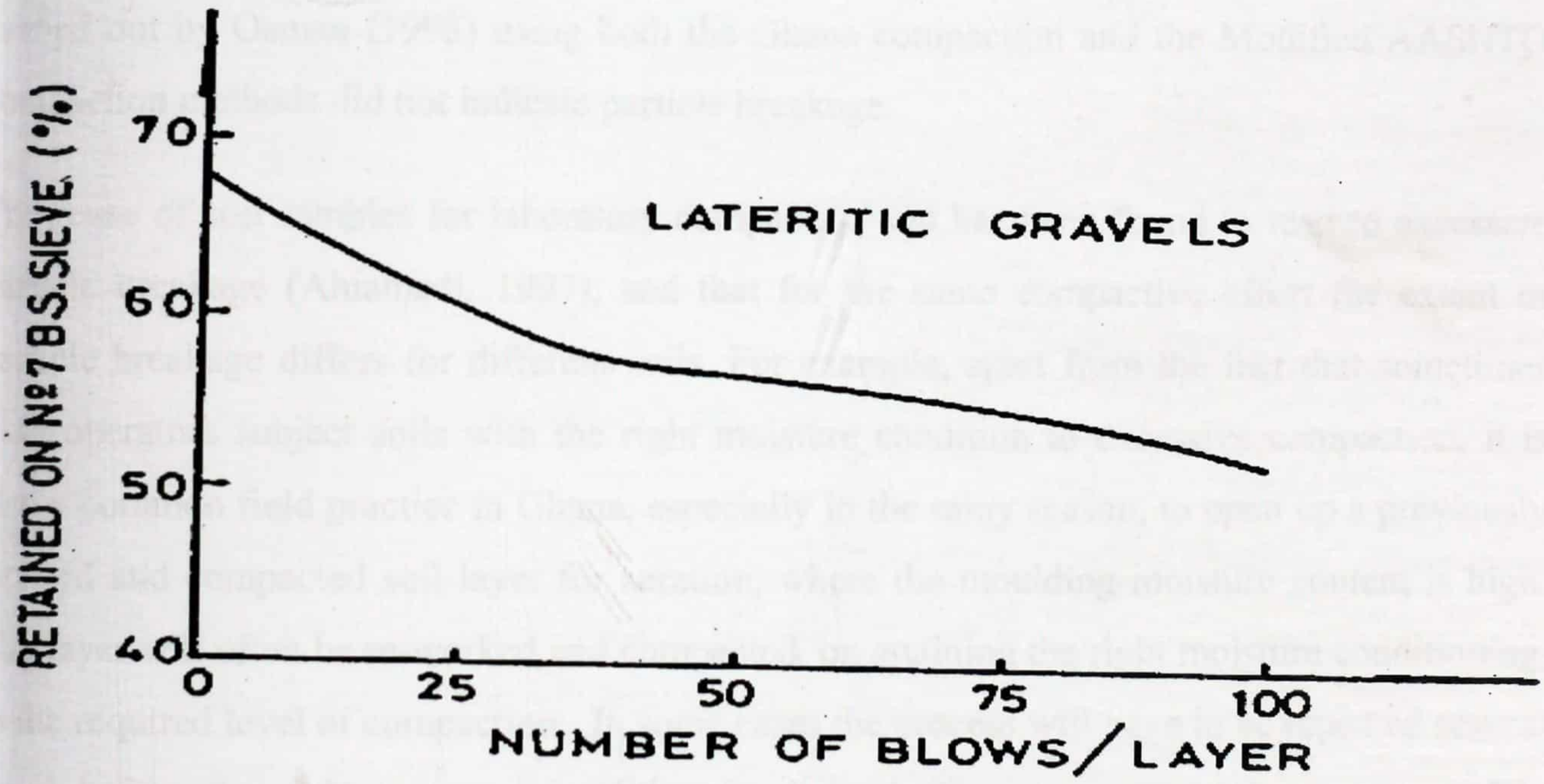

Figure 3.11 Effect of compactive effort on particle breakages in lateritic gravels (after Gidigasu and Dogdey, 1980)

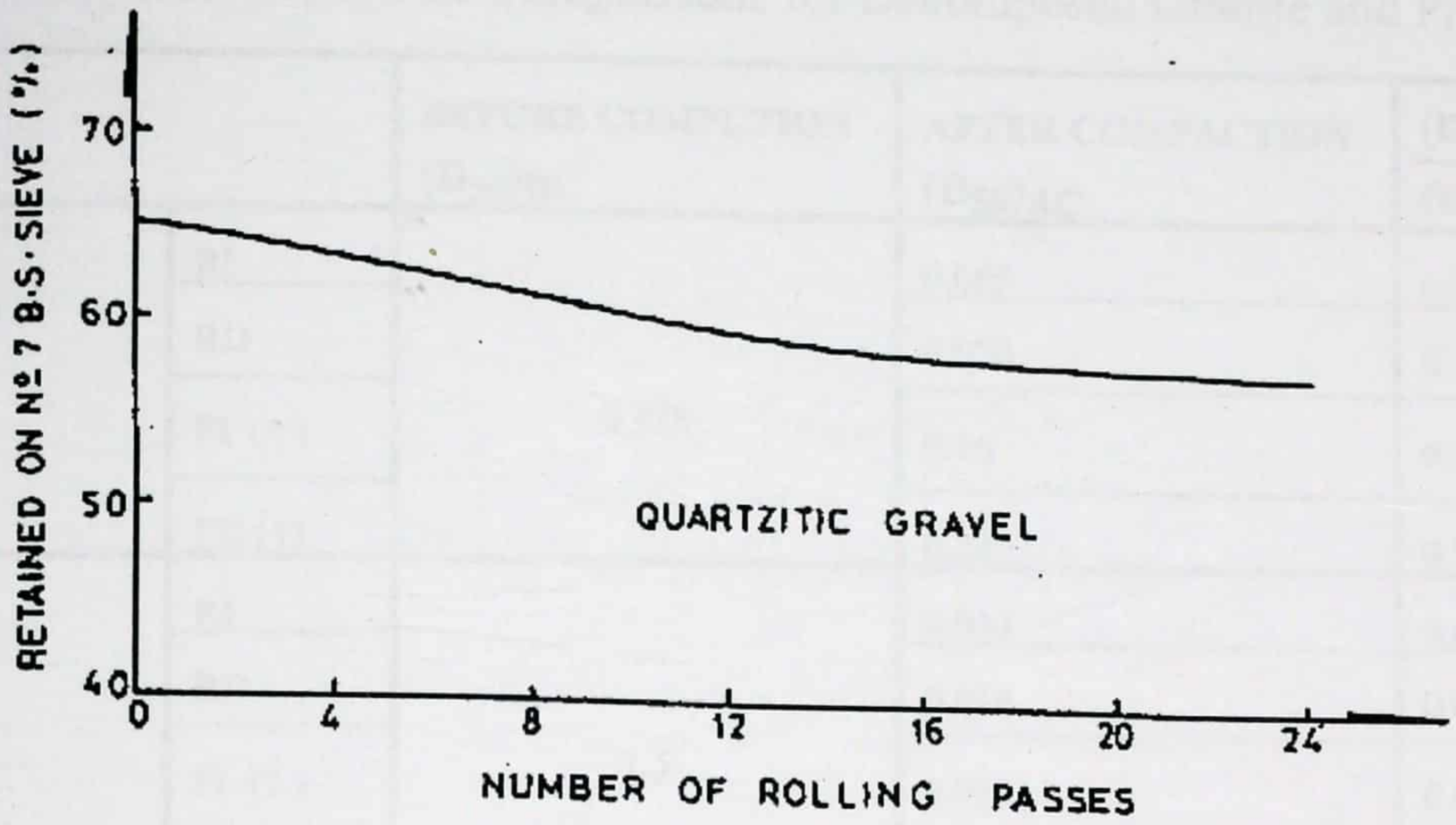

Figure 3.12 Effect of roller passes on particle breakages in quarzitic gravels (after Gidigasu and Dogdey, 1980)

However, laboratory compaction studies on decomposed Granite and decomposed Phyllite carried out by Osman (1998) using both the Ghana compaction and the Modified AASHTO compaction methods did not indicate particle breakage.

The reuse of soil samples for laboratory compaction test has been found to lead to excessive particle breakage (Ahiamadi, 1997), and that for the same compactive effort the extent of particle breakage differs for different soils. For example, apart from the fact that sometimes field operators subject soils with the right moisture condition to excessive compaction, it is also a common field practice in Ghana, especially in the rainy season, to open up a previously worked and compacted soil layer for aeration, where the moulding moisture content is high. The layer will often be re-worked and compacted, on attaining the right moisture conditioning, to the required level of compaction. In some cases the process will have to be repeated several times before the right moisture condition is attained. The same approach is also used in conditioning the moisture content when the moisture during moulding is too low, as is often the case during construction in the dry seasons of Ghana. For example, when one applies this method to the compaction studies of Ahiamadi (1997), on decomposed granite and phyllite, one will obtain the results shown in Table 3.2. The ratios for the granite are of higher values, thus suggesting lesser particle breakage, whereas, for the phyllite lower values were obtained, with these suggesting higher particle breakages in the soil material.

Table 3.2 Median Grain Size Comparisons for Decomposed Granite and Phyllite

MATERIALS		BEFORE COMPCTION $(D_{50})_{BC}$	AFTER COMPACTION $(D_{50})_{AC}$	$\frac{(D_{50})_{AC}}{(D_{50})_{BC}}$
DECOMPOSED GRANITE	RI	0.420	0.065	0.15
	RD		0.070	0.17
	FI (1)		0.16	0.38
	FD (1)		0.24	0.57
DECOMPOSED PHYLLITE	RI	1.5	0.034	0.02
	RD		0.014	0.01
	FI (1)		0.028	0.02
	FD (1)		0.014	0.01

RI = Sample re-used with increasing moisture content; RD = Sample re-used with decreasing moisture content. FI (1) = Fresh sample used with increasing moisture content (for point 1); RD = Fresh sample used with decreasing moisture content (point 1).

Thus, some of the test results obtained indicate that, for the same compactive effort, the extent of particle breakage are different for different soils, whereas, the extent of particle breakage are also different for different compactive efforts, for the same soil, in both laboratory and field compactions.

3.5 Effect of Compaction on Plasticity Index.

For the geotechnical properties of pavement construction materials, two limits are of great importance. These are the liquid limit (LL) and the plastic limit (PL), which have been established empirically and are universally recognised. Whereas, the liquid limit defines the minimum moisture content at which the soil begins to flow, the plastic limit defines the minimum moisture content at which the soil begins to behave as a plastic material. Thus, the two limits form the boundaries of the moisture range within which the soil material is said to be in a plastic state. This moisture range, often referred to as the plasticity index (PI), is measured as the difference between the liquid limit and the plastic limit. Theoretically, plasticity index is strongly influenced by the amount of clay present in the soil material. As illustrated in Figure 3.13, with increasing clay content, both the liquid and plastic limit increase, with the former increasing at a much faster rate than the latter, thereby causing the plasticity index to increase at a rapid rate. On the other hand, decreasing the clay content

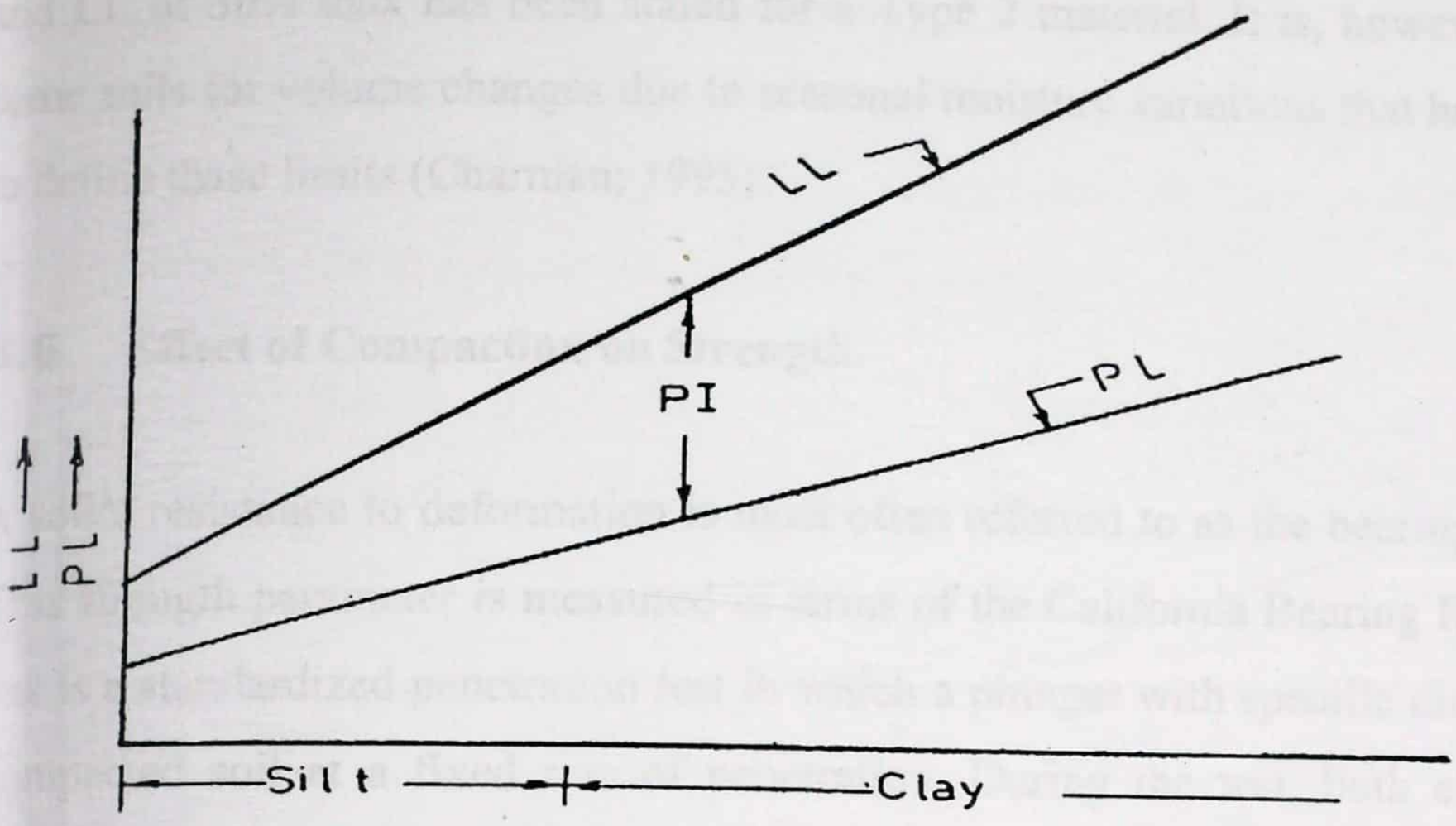

Figure 3.13 The effect of Particle Size Distribution on Plasticity Index

(after Arore, K.R: 1997)

means adding some silt material and this have the tendency of reducing the plasticity index. In practice, however, these index properties (liquid limit and plastic limit), can only be evaluated for soils with some cohesion, on the fraction of material passing the 425μm sieve. Particle breakage during compaction leads to larger size particles being broken down into smaller size particles. A loss in larger size particles generally means a corresponding gain in smaller size particles. This suggests the tendency for the plasticity index of a soil material to improve or become poor as a result of a gain in smaller size particles due to the breakdown of larger size particles during compaction.

The content of fines in a soil material is intrinsically linked with its plasticity, hence the concept of combining the plasticity index and the proportion of finer material in modern specifications. This concept is however, defined in some specifications as Plasticity modulus, but in others as Plasticity product. Whereas, Plasticity modulus is simply the product of the Plasticity index and the percentage of material passing the 425-micron test sieve, Plasticity product is the product of the Plasticity index and the percentage of material passing the 75-micron test sieve. Thus, both terms represents the effective contribution of the plasticity of the fines to the performance of the whole soil material. In Ghana, however, it is the Plasticity Modulus, which is used. The specification of MRH; 1991, defines 35% max and 15% max respectively as the LL and PI, for a gravel sub-base material; and a LL of 35% max and, 5%-12% PI for sub-base material of sands, silty and clayey sands. For base material, a PI of 10% max and a LL of 25% max has been allowed for a Type 1 material, whereas a PI of 15% max

and LL of 30% max has been stated for a Type 2 material. It is, however, the propensity of some soils for volume changes due to seasonal moisture variations that have made it necessary to define these limits (Charman; 1995).

3.6 Effect of Compaction on Strength.

A soil's resistance to deformation is most often referred to as the bearing capacity of the soil. This strength parameter is measured in terms of the California Bearing Ratio, CBR. The CBR test is a standardized penetration test in which a plunger with specific dimensions penetrates a compacted soil at a fixed rate of penetration. During the test, both elastic and permanent deformations occur and when the penetration continues, finally failure is observed. A generally adopted failure mechanism, which is shear in nature, is shown in Figure 3.14.

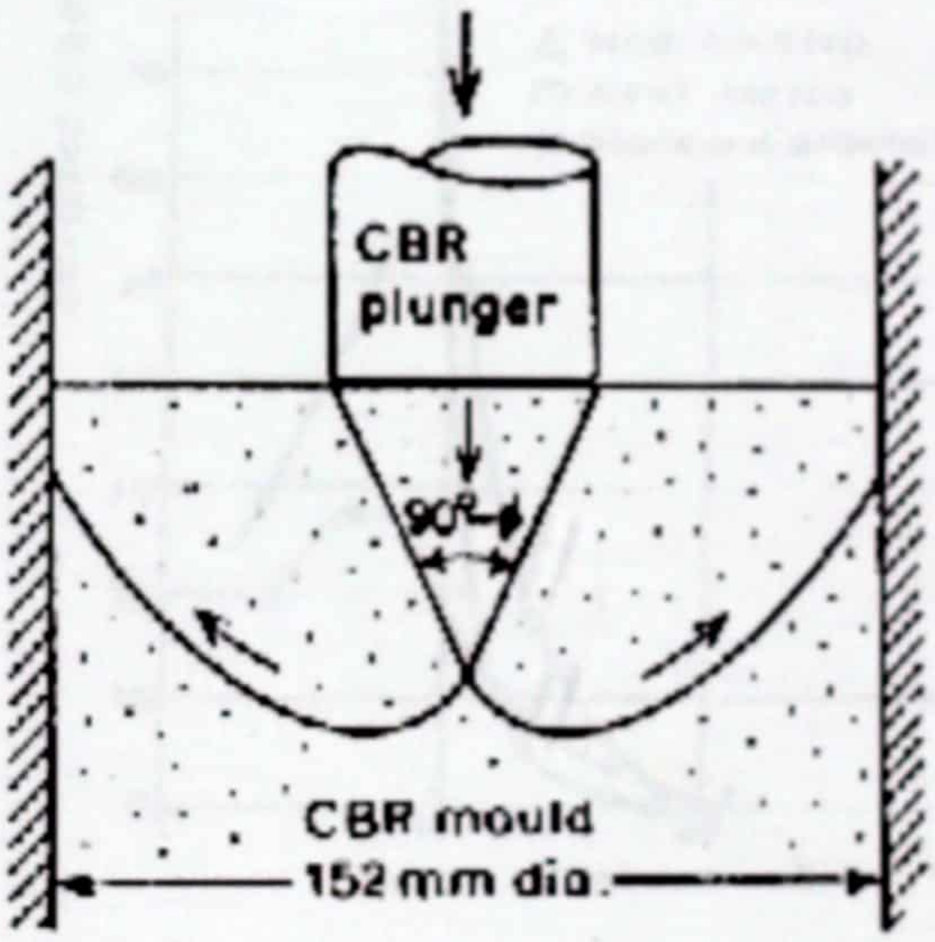

Figure 3.14 Assumed failure mechanism of soil under the CBR Plunger

(after Galjaard, 1996)

For pavement construction in Ghana, CBR values of 80% and 40% have been specified for base and sub-base materials respectively as the minimum required. These values, however, corresponds to a 95% Maximum Dry Density (obtained by the AASHTO - T180 compaction method) after 4 days soaking. The testing of soaked samples, however, is to simulate the worse field condition likely to be experienced by the road structure due to the action of water. Since the CBR test is carried out on compacted specimen, the particle size gradation finally attained at compaction stage is likely to have some influence on the CBR values obtained. More generally, at lower moisture contents higher dry densities are obtained with increasing

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compactive efforts. Whereas this condition usually lead to the attainment of higher CBR values for some soils, lower CBR values occur when compaction is done at moisture contents wet of the optimum, Hammond, (1970). The lower strength reported here is however, attributed to the effect of particle breakages that occur during the comp-

action process. One of such typical relationship between the CBR and moisture content for different compactive efforts is given in Figure 3.15.

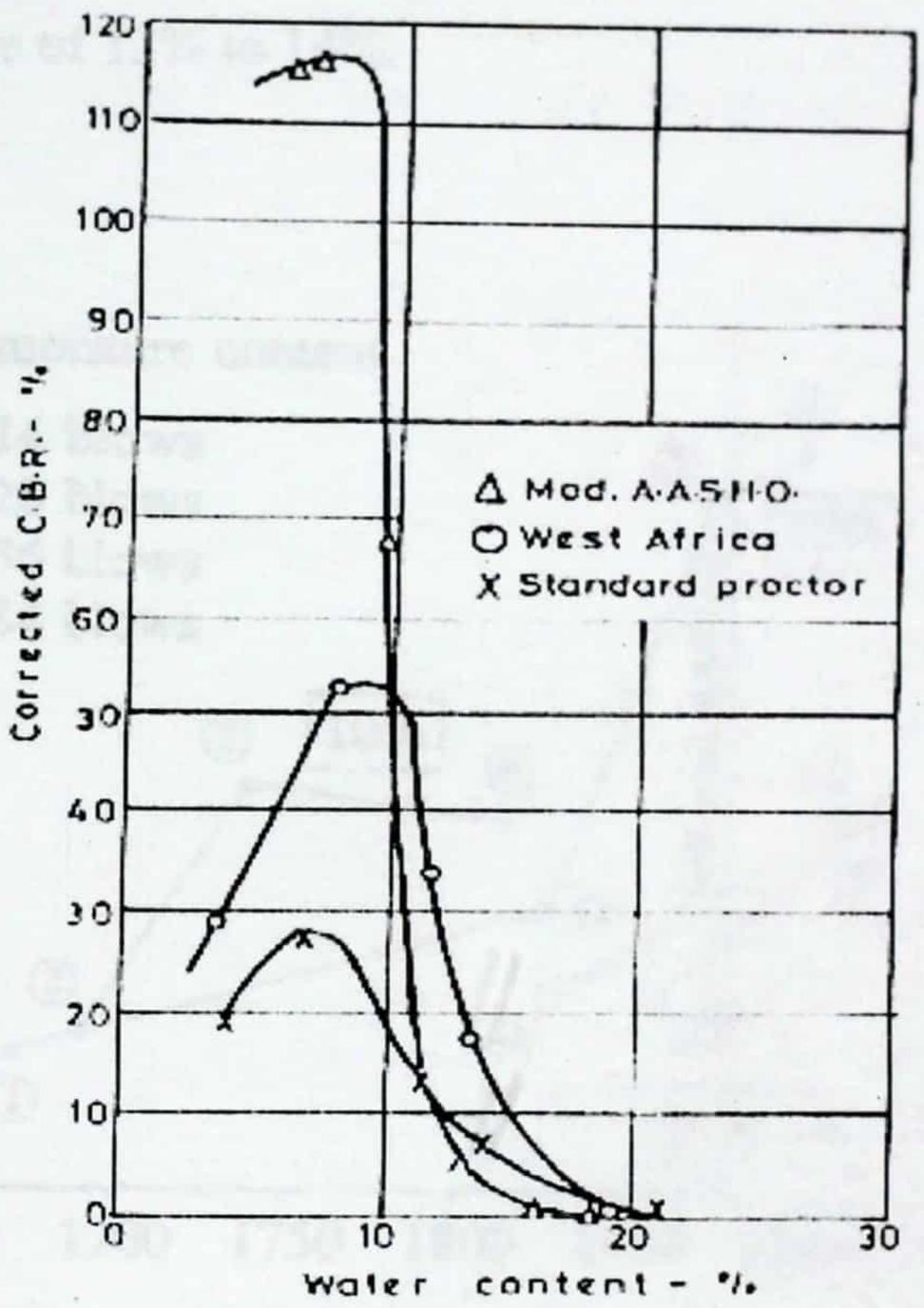

Figure 3.15 Moisture content - CBR relationship for a lateritic soil (after Hammond 1970)

Note that for each compactive effort, the CBR increased with increasing moisture contents up to a certain moisture limit, beyond which it began to drop with increasing moisture contents. However, the drop in CBR values for the higher compactive effort occurred wet of the optimum than for the lower compactive efforts, which experienced a drop in CBR even on the dry side of the optimum. This study was carried out on four different lateritic gravel samples taken from the Kumasi municipality of Ghana. The results for the other lateritic gravel soils showed a trend similar to that indicated above.

Gaijaard (1997), had also made a similar observation after using the "Family of curves" method discussed in Highway Materials by Krebs and Walker (1971) in his studies on a laterite

soil obtained from the Western Region of Ghana (see Figure 3.16). Note that the family of curve is simply the plot on one graph of the soaked CBR as a function of the dry density for different moulding water contents and at various levels of compaction. The test results indicate that at 10 % moisture content the CBR of about 28 % for 56 blows decreased to 25 % for 84 blows. This could be attributed to lack of moisture to facilitate adequate repacking effect especially at the higher compactive efforts. Again, the absence of adequate moisture often leads to particle breakage through frictional contacts. This may affect the general strength of the compacted material. It must be noted that the same soil material shows increases in strength at 84 blows for moisture range of 12% to 14%.

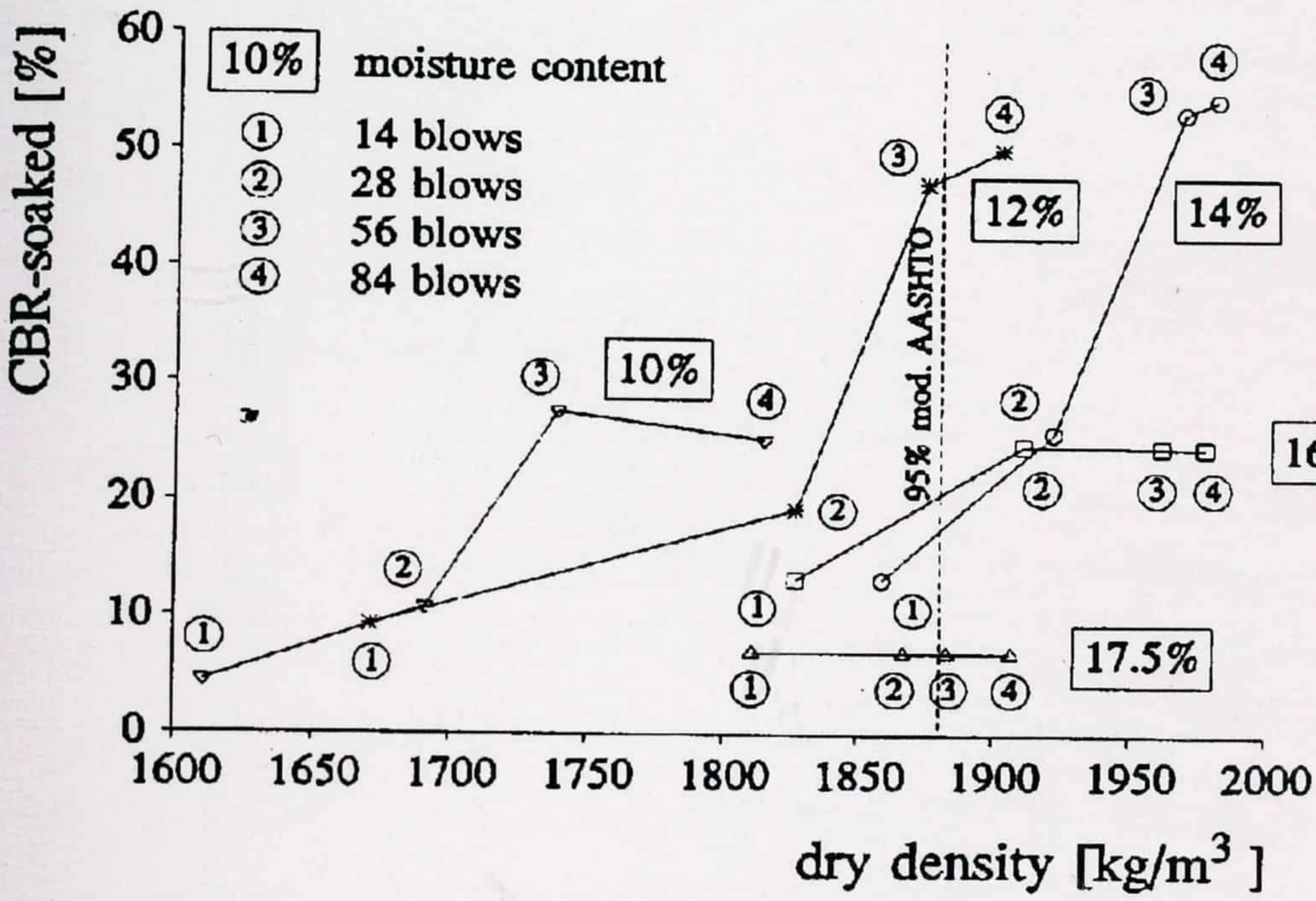

Figure 3.16 Family of curves for a laterite soil from the Western Region of Ghana

3.7 Effect of Moulding Water Content on Particle Breakage

Moisture content as indicated earlier facilitates the re-packing of soil particles into a dense material during compaction. Often, moisture control is left to the judgment of the engineer on the job. Thus, the relative moisture condition of a soil is judged by feel and by visual examination.

Again, using the median grain size concept, the test results of the studies carried out by Ahiamadi (1997), as described previously, indicate that for the decomposed granite increasing moisture content from 6% to 24% gives particle breakage varying from 31% to 82% whereas,

decreasing the moisture content from 23% to 13% gives particle breakage varying from 64% to 19%. The results further indicates that for the decomposed phyllite increasing the moisture content from 11% to 22% gave particle breakage varying from 2% to 19% whereas, decreasing the moisture content from 26% to 14% gave particle breakage varying from 1.0% to 2%. Note that higher percentage value of the ratio D_{50} (after compaction) to D_{50} (before compaction) is an indication of lesser particle breakage, whereas lower percentage value obtained for the same ratio, indicates higher particle breakages.

4. METHODOLOGY

4.1 Outline of Methodology

In order to accomplish the stated objectives of this study, the following three studies were undertaken:

(a) Laboratory Compaction Studies

(b) Model Site Compaction Studies

(c) Construction Site Compaction Studies

4.2 Laboratory Compaction Studies

4.2.1 *Sampling and sample preparation*

4.2.1.1 Sampling

The soil samples used in the studies consist of both sub-base and base quality materials. These soil materials had earlier on been tested and found suitable for use in the construction of the sub-base or base layers of some road projects which were on-going in the three agro-ecological zones of Ghana, as shown in Figure 2.4, during the period from 1999 to 2001. For the purpose of this study, the said road projects have been identified by codes, as shown in Table 4.1.

The total number of soil samples acquired and used in the Laboratory Compaction Studies was ten (10). The distribution of the different sources from which the soil samples were obtained, were as follows: Northern Region – 2 nos, Ashanti Region – 3 nos, Brong-Ahafo Region – 1 no, Western Region – 2 nos, Greater Accra Region – 1 no, and Volta Region – 1 no. Sampling had basically involved scooping the respective soil samples into sample bags, with the aid of shovels, from stockpiles of gravel material in either borrow pits, or purpose made gravel stockpile yards (as shown in Photo 4), or gravel materials dumped on the road and were yet to be spread out with the aid of a grader, for further processing (as shown in Photo 5).

Table 4.1 Source of Soil Samples for Laboratory Compaction Studies

Zone	Source of Materials	Type of Materials	Project Code
1	Stockpile yard (Near road side)	Base	T-K (B)
	Material dumped on the road in heaps but not yet spread out	Sub-base	T-K (SB)
2	Material dumped on the road in heaps but not yet spread out	Sub-base	JZ-Y (SB)
	Stockpile (Borrow pit)	Sub-base	L –BP (SB)
	Material dumped on the road in heaps but not yet spread out	Sub-base	K-A (SB)
	Material dumped on the road in heaps but not yet spread out	Base	GR-(B)
	Material dumped on the road in heaps but not yet spread out	Sub-base	A-N (SB)
	Material dumped on the road in heaps but not yet spread out	Base	JB (B)
3	Material dumped on the road in heaps but not yet spread out	Base	AJ-AD (SB)
	Stockpile (Borrow pit)	Sub-base	K-W (SB)

Table 4.1 shows in detail, the summary of the various sources from which the soil samples were obtained.

4.2.1.2 Sample Preparation

The preparation of the various soil samples at the laboratory involved air drying at room temperature, then thorough mixing. The samples were then sieved through a 20 mm BS Test Sieve, with material retained appropriately replaced. Representative test samples, designated the raw samples, as shown in Table 4.2 were obtained using a riffle box.

Photo 4 Sampling of material (top section, mid section and bottom section, T-K (B)

Photo 5 Truck discharging sub-base material onto the road within a Test Section of a road

Table 4.2 Sample Weights prepared for the various Laboratory Tests.

Test	Laboratory Un-compacted Soil Samples	Laboratory Compacted Soil Samples (Material processed as explained in subsection 5.2.1.2)		
	0 blows	10 blows	25 blows	55 blows
Atterberg	Liquid Limit (200 g) Plastic Limit (200 g)	Liquid Limit (200 g) Plastic Limit (200 g)	Liquid Limit (200 g) Plastic Limit (200 g)	Liquid Limit (200 g) Plastic Limit (200 g)
Grading	Wet Sieving (1000 g or 1500 g) Sedimentation (50 g)	Wet Sieving (1000 g or 1500 g) Sedimentation (50 g)	Wet Sieving (1000 g or 1500 g) Sedimentation (50 g)	Wet Sieving (1000 g or 1500 g) Sedimentation (50 g)
Compaction	48 kg	Not applicable		
CBR	Not applicable	Un-soaked (16 kg) Soaked (16 kg)	Un-soaked (16 kg) Soaked (16 kg)	Un-soaked (16 kg) Soaked (16 kg)

4.2.2 *Testing of the Selected Soil Samples*

4.2.2.1 MDD and O.M.C relationship determination test

The test samples for the Maximum Dry Density determination test were sieved through a 20 mm BS Test Sieve with material retained appropriately replaced with material passing the 20 mm test sieve but retained on the 5 mm BS test sieve. For each source of material, one of the 8 kg weight samples was taken and conditioned at moisture content far less than the expected optimum moisture content. The wet sample was then mixed thoroughly and covered with polythene sheet and left to stay for about 15 minutes. The sample was compacted in five layers at 56 blows per layer using a 4.54 kg rammer.

The collar of the mould was then removed and the surface of the compacted soil trimmed off to flush with the top of the mould. The mass of the mould, base plate, and the compacted soil were then determined. The mass of the compacted soil was then found. This was followed by the computation of the bulk density of the soil. The mould was emptied of its content and representative soil samples taken for moisture content determination. The dry density of the compacted soil was computed from the bulk density and the moisture content values previously determined.

For each soil, the test procedure and calculations were repeated for the remaining 8 kg weight test samples, by adding water that was about 2% higher than that of the previous mix, until the wet weight of the soil had fallen the second time. Plots of dry density and moisture content were used to determine the optimum moisture content of the soil material.

4.2.2.2 Laboratory Compaction Tests

The laboratory compaction studies were carried out using the compaction rammer and mould specification shown in Table 4.3.

Table 4.3 The Specification of the Compaction Rammer and Mould

Hammer Weight (kg)	4.54
Hammer drop height (m)	0.457
Mould diameter (m)	0.152
Mould height (m)	0.1165
Mould Volume (m^3)	0.002115
No. of layers	5

For each material source, nine (9) sets of 8 kg weight of raw samples were prepared for the 10, 25, and 55 blows laboratory compaction studies (see Tables 4.2). Each raw sample had initially been moisture conditioned to the optimum moisture content of the soil in question. Again, each set was subjected to compaction in a mould, in five layers, using the 4.54 kg weight rammer. The number of blows per layer for each three sets of raw samples, were however, varied in the order of 10, 25, 55 blows.

4.2.2.3 Atterberg Limits

Out of each of the ten sources of material indicated in Table 4.1, four raw samples were obtained. One of the four raw samples was then divided into two halves, with the aid of a riffle box. One half of the sample was then sieved through the 0.425 mm BS test sieve to obtain the Laboratory Un-compacted Sample for the Atterberg Limit Test, as shown in Table 4.2. It must be noted here that the other half was also sampled and used as the Laboratory Un-compacted Sample for Grading Analysis, as discussed under Laboratory Compaction Tests. These samples were however, still referred to as 0 blow samples.

The other three raw samples, compacted to 10, 25, and 55 blows, were thereafter, removed from the compaction moulds and then air dried at room temperature in trays. Samples were then taken for Atterberg Limit test and grading analysis. The tests were carried out in accordance with the BS 1377, Part 2.

4.2.2.4 Particle Size Distribution Test

The samples used were obtained in the same manner as discussed above. Both the wet sieving method and the hydrometer method, of BS 1377, Part 1 and Part 2 respectively, were used in the particle size distribution analysis for the soil samples.

The respective test samples were sieved on the 2.36mm test sieve and the material passing was collected for the hydrometer test. The materials retained on the test sieve were then soaked in water for 24 hours, and thereafter washed carefully under a flowing tap water, on the 2.36 mm test sieve. The washed samples were then oven dried for 24 hours, before sieving through a set of nested test sieves, ranging from 50.8mm down to 0.075mm, in a mechanical shaker.

The weight of materials retained on each test sieve was then determined and recorded. The percentages of material passing each test sieve were thereafter computed to the nearest whole number.

For the Sedimentation by the hydrometer method for each test sample, the material passing the 2.36mm sieve was collected, and 50 g weight of it was taken and placed in a measuring cylinder. A dispersing agent consisting of 33 g sodium hexametaphosphate and 7 g Sodium Carbonate in a solution of 1000 cm^3 was then prepared. 100cm^3 of this solution was taken and mixed with the test sample in the measuring cylinder. The soil-water mixture was then topped with distilled water to the 1000 cm^3 marks and thoroughly stirred for 15 minutes and then left to stand overnight. The soil-water mixture was again shaken and topped to the 1000 cm^3 mark. Thereafter, the rate of settlement of the soil particles was observed by measuring and recording, at different time intervals, the rate of fall of a hydrometer placed in the soil-water solution. The test data was later reduced to provide particle diameters and the percentage (weight) that is finer than a particular size determined. These were then plotted on a semi log graph paper.

4.2.2.5 California Bearing Ratio (CBR) Test

For each of the ten sources of material indicated in Table 4.1, a set of six previously uncompacted samples were prepared for the CBR test (three for the un-soaked and the other three for the soaked condition) as shown in Table 4.2.

Each of the samples was then moisture conditioned at the optimum moisture content, and covered with polythene sheet for about 15 minutes. The conditioned sample was then compacted in five layers at 55 blows per layer. The mould was disassembled and rearranged, this time with the displacement block removed and the main body turned upside down. A surcharge load of 4.5 kg was then placed on top of the compacted soil material. The compaction procedure was repeated using 25 blows and 10 blows/ layer. For a given number of blows, two samples were prepared so that one could be used for unsoaked CBR and the other soaked CBR determination.

Un-soaked Compacted Samples

Bulk densities were determined before unsoaked compacted samples were subjected to CBR penetration tests. In the CBR test, a cylindrical metal plunger of 50 mm diameter was made to penetrate the compacted samples at a rate of 1 mm / min. The dial gauge readings, of the force generated between the plunger and the test sample, were then taken at intervals of penetration of 0.25 mm up to a total penetration of 8.0 mm. The CBR values of the compacted samples were then computed by dividing the force readings obtained for the penetrations of 2.5 mm and 5mm respectively by that of the standard forces, 13.24 kN and 19.96 kN, obtained for crush rock. The values obtained were then expressed in percentages with the largest of the two being taken as the CBR value.

On completion of the penetration test on each un-soaked compacted sample, two soil samples were taken from the soil material removed from the mould for moisture content test and subsequently dry density computation.

Soaked Compacted Samples

The mass of the mould, perforated base plate, and the compacted soil, was first determined and recorded. The mass of the compacted soil, before soaking, was thus computed. This was followed by the computation of the bulk density before soaking. Portions of the sample used for compaction and oven dried for 24 hours, for moisture content computations. The data obtained were then used for dry density computations.

The compacted samples were then immersed in water for a period of four days. At the end of the soaking period, the samples were removed from water and kept at a suitable place for the water on the body of the mould to drain away. The mass of the mould, perforated base plate,

and the compacted soil, was then determined. The mass of the compacted soil, after soaking, was thus computed. This was followed by the computation of the bulk density after soaking. CBR penetration tests were then carried out on the samples. After the test, samples were taken for moisture content determination. This was followed by the computation of the dry densities.

4.3 Model Site Compaction Studies

4.3.1 *Site Description*

A test study site, about 100 m in length and located on the Tepa side of the approach road to the Kusu Bridge, which is on the Goaso–Tepa road, in the Brong-Ahafo Region of Ghana, was identified and used in the studies. The layout of the Test Site has been shown in Figure 4.1.

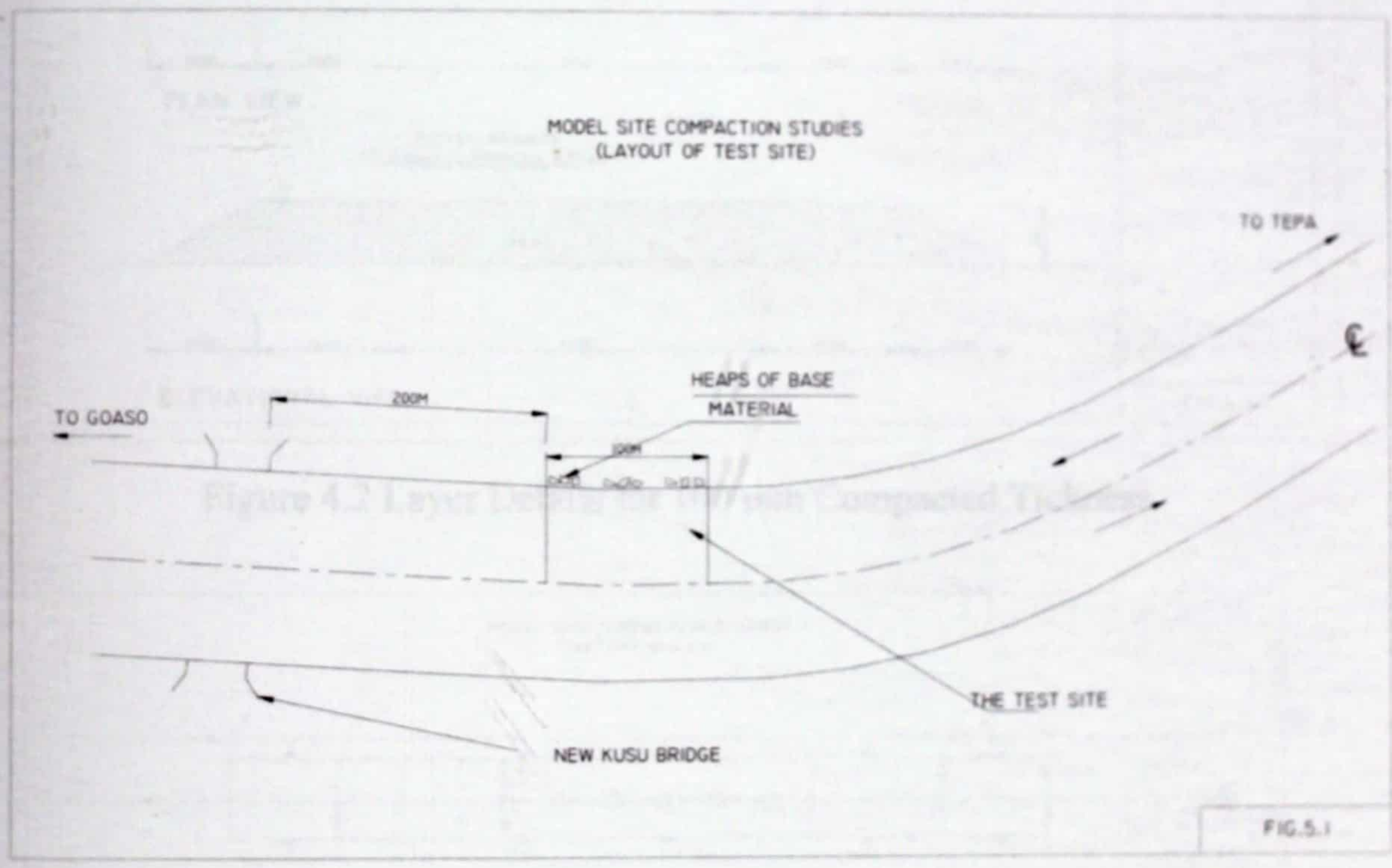

Figure 4.1 Layout of Model Site Compaction Studies Test Site

Laterite of base quality with a high proportion of slightly weathered rock fragments was used for the studies. The material designated "Model Site Raw Sample" was acquired from a borrow pit near a village called Maabang, near Tepa. Again, the material in question had in actual fact formed part of the material used in the construction of the base layer of the Kusu River bridge approaches by Messrs Kasap Limited.

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The "Model Site Raw Sample" was kept in dumped heaps along the outer edge of the Test Site. As and when needed, it was spread out by a motor grader to form a set of three loose lift beds, of thickness of 120 mm, 170 mm and 220 mm. Each loose lift bed was approximately 7 m in length and varied in width, depending on the width of the compaction plant to be used. Each corresponded to the compacted thickness of 100 mm, 150 mm and 200 mm, as shown in Figure 4.2 -4.4. In all, a total of three sets of three loose lift beds, were formed. Photo 6 shows a motor grader spreading out material to form a 170 mm loose bed for the 8,559 kg static roller.

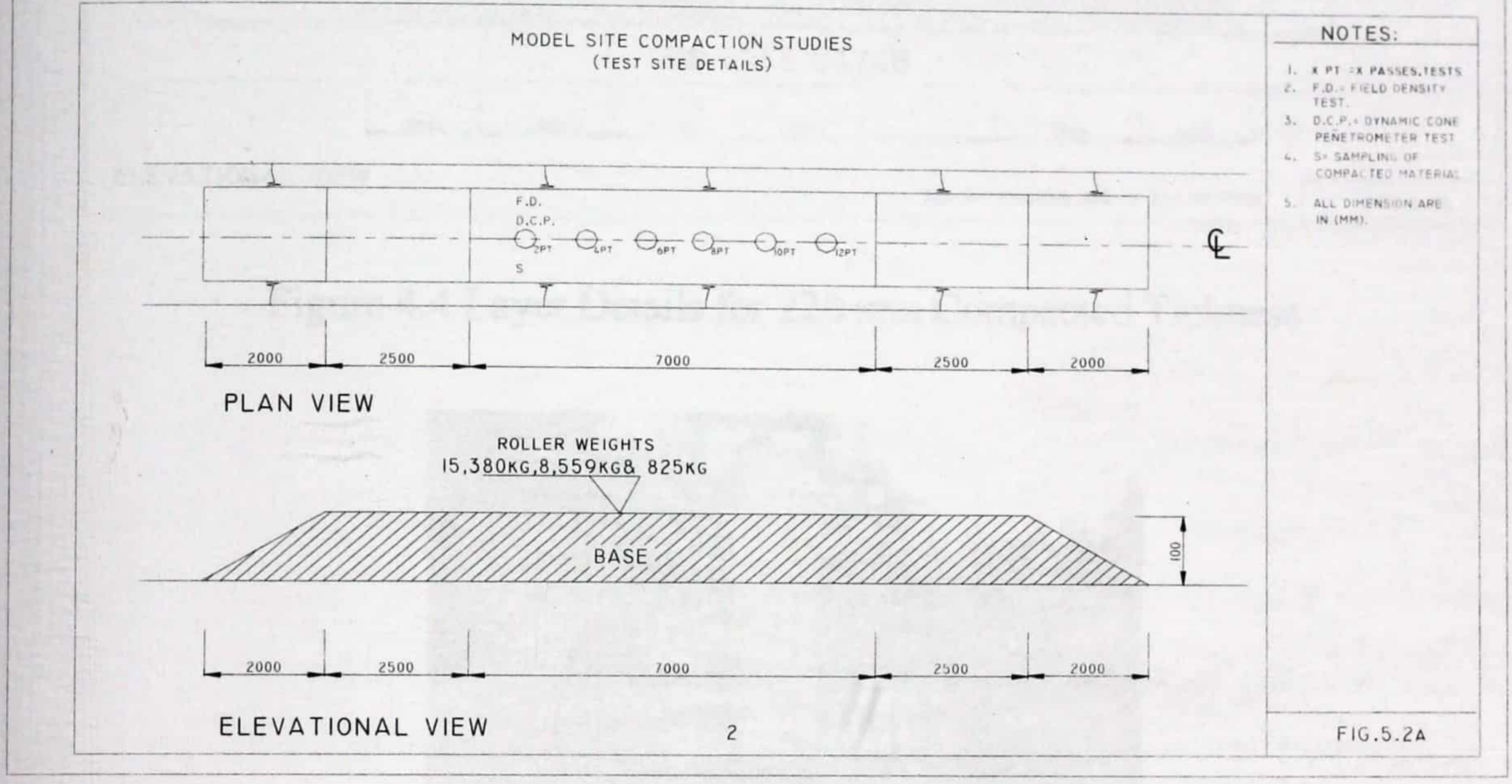


Figure 4.2 Layer Details for 100 mm Compacted Tickness

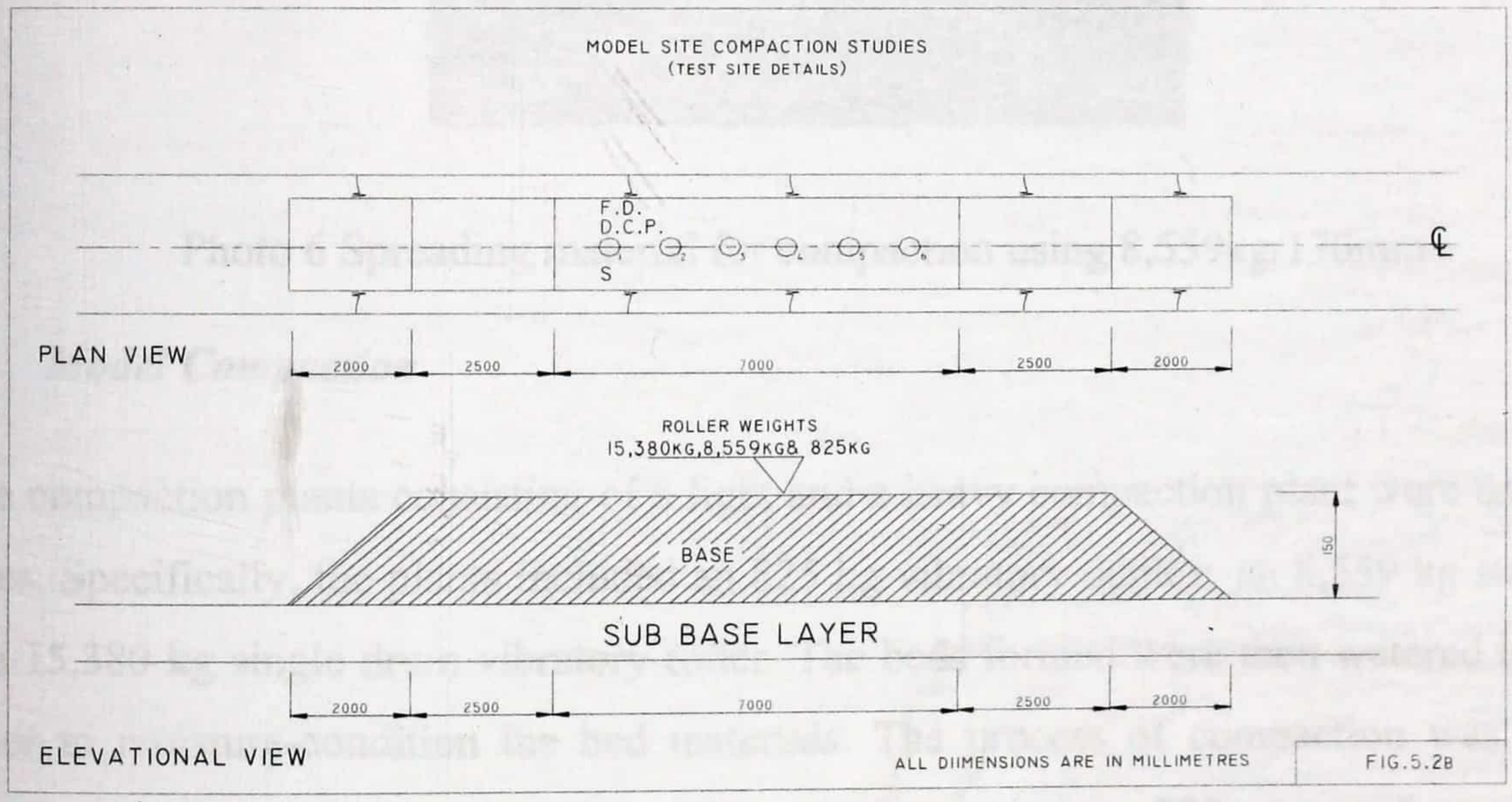


Figure 4.3 Layer Details for 170 mm Compacted Tickness

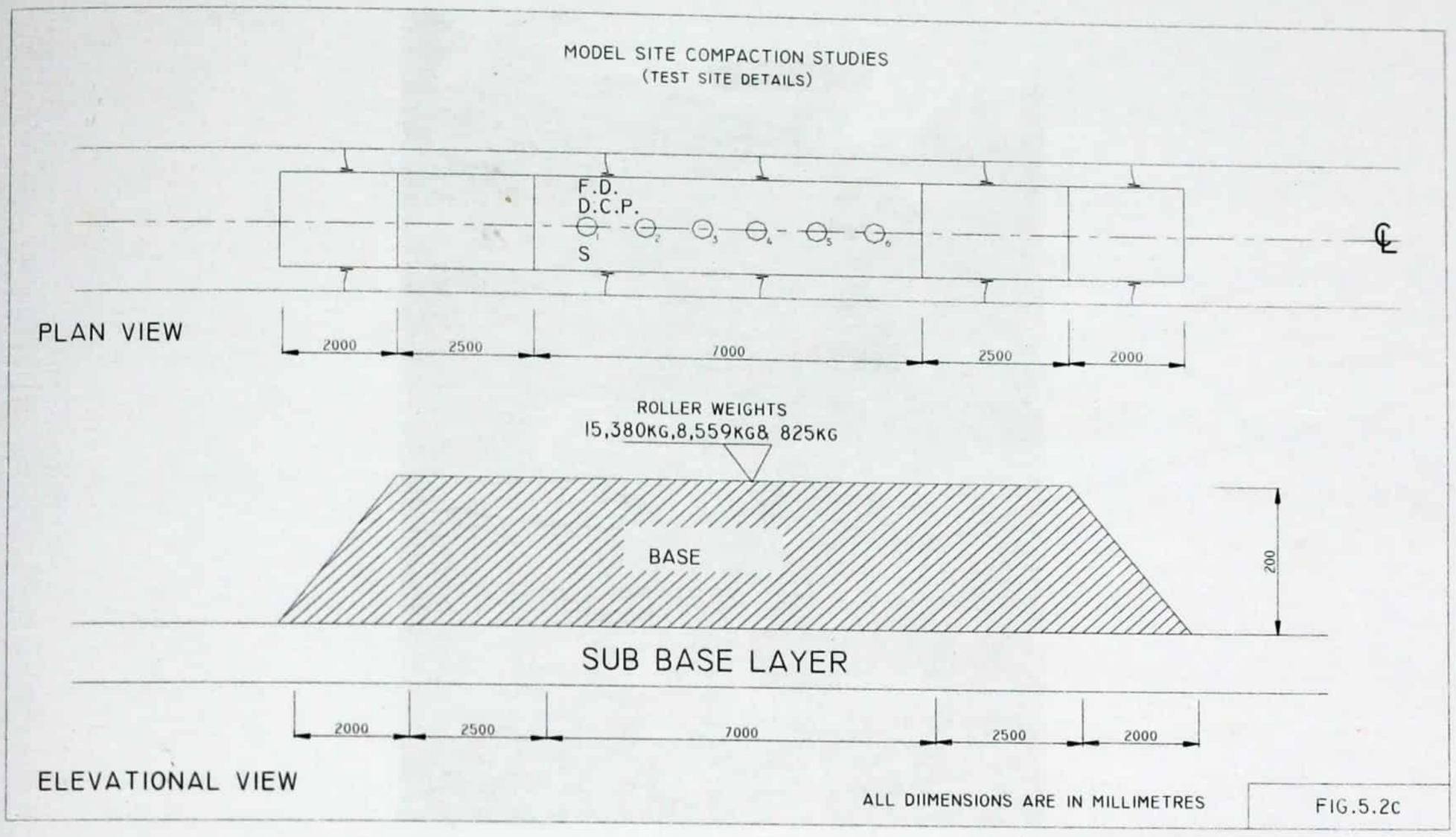


Figure 4.4 Layer Details for 220 mm Compacted Tickness

Photo 6 Spreading material for compaction using 8,559kg/170mm

4.3.2 *Model Compaction*

Three compaction plants consisting of a light and a heavy compaction plant were used for the studies. Specifically, the plants included an 825 kg vibratory duplex, an 8,559 kg static roller, and a 15,380 kg single drum vibratory roller. The beds formed were then watered by a water bowser to moisture-condition the bed materials. The process of compaction was thereafter started, with the 8,559 kg static roller making two passes on the 220mm mm loose lift bed as shown in Photo 7

Photo 7 Material Condition after 2 passes of 8,559kg/170mm

The density achieved and the level of strength gained by the bed material was then measured using the sand replacement method and the DCP test respectively. Samples of the compacted soil material were also taken for testing at the laboratory. Such samples were designated "Model Site Compacted Samples". The scope of testing under the Model Site Compaction Studies is summarised in Table 4.6 below. The process of compaction was then continued, and field testing of the compacted bed and sampling of compacted material for laboratory testing was repeated after every two passes of the compaction plant, up to twelve passes. Using the 8,559 kg static roller, the process was repeated for the 120 mm and 170 mm loose lift beds as well. Similar compaction was carried out using the 825 kg vibratory duplex and the 15,380 kg single drum vibratory roller on the other two sets of three loose lift beds.

Table 4.4 Scope of Testing under the Model Site Compaction Studies

Operating Weight of Compaction Plant (kg)	Compacted thickness (mm)	No. of Passes (No)	The Parameters Measured	
			Field Tests	Laboratory Tests
825 8,559 15,380	100	2, 4, 6, 8, 10, 12	In-situ Density & CBR (by DCP)	Atterberg limits & Grading Analysis
	150			
	200			

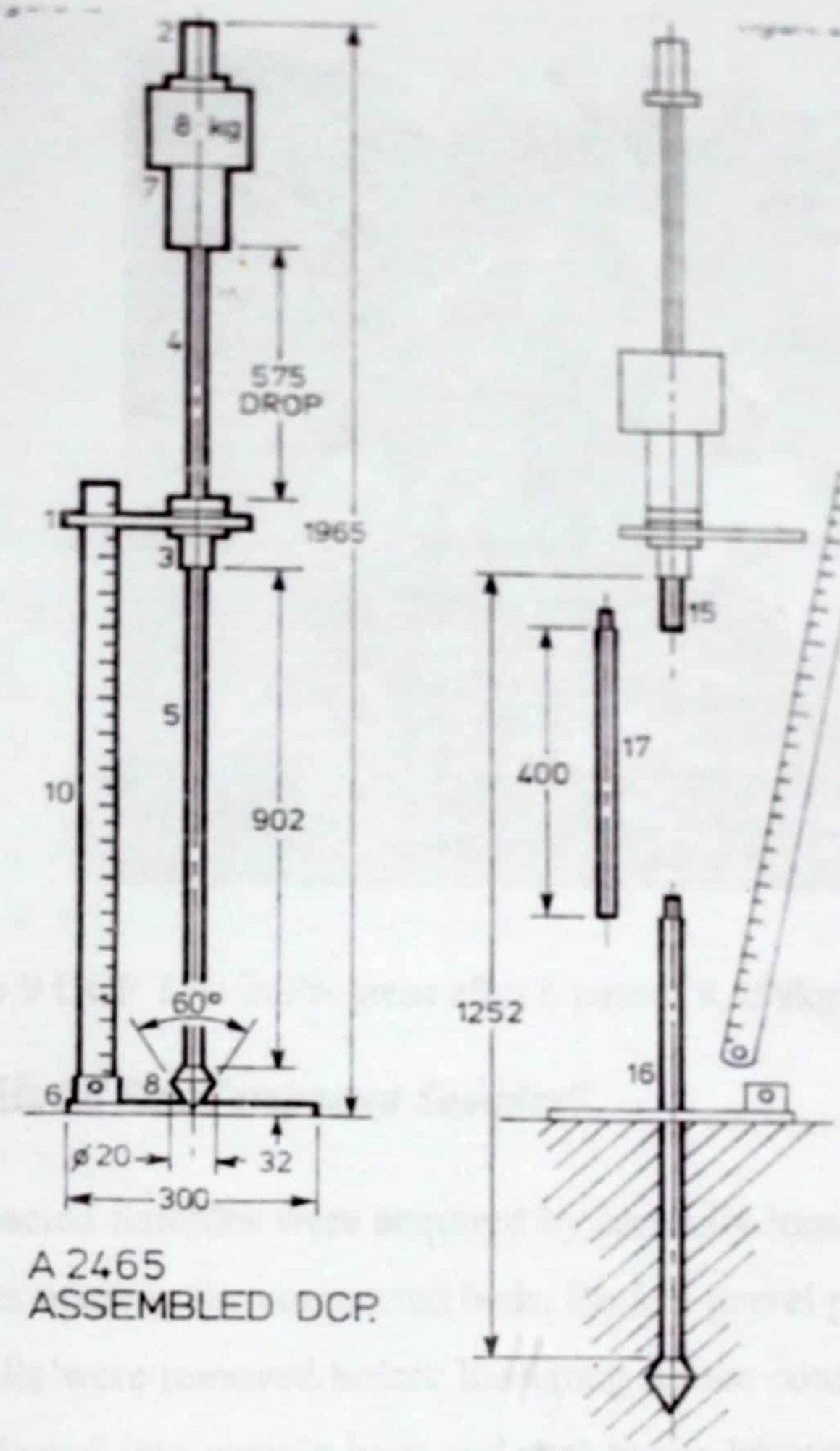
5.3.3 Field Density Test

Field densities were carried out after every two passes of each selected roller using the sand replacement test method. The moisture content of the soil was also determined using the speedy moisture tester. The dry density of the soil was then computed. From the laboratory maximum dry density value, the level of compaction achieved after every two passes was computed. In all, a total of fifty one (51) levels of compaction results were computed. Photo 8 shows a Field Density test being carried out during the Model Site Compaction Studies.

Photo 8 Density Test after 10 passes 15,380 kg/220mm

4.3.3 *DCP Test*

The DCP instrument is designed for the rapid in-situ measurement of the structural properties of existing road pavements constructed with unbound materials. Continuous measurements can be made down to a depth of approximately 850 mm or more when extension shafts are used. Where pavement layers have different strengths the boundaries can be identified and the thickness of the layers determined. The instrument used is the TRRL (DCP A2465) shown in Figure 4.5. The instrument uses an 8 kg weight dropping through a height of 575 mm and a 60^0 cone having a diameter of 20 mm.



A 2465
ASSEMBLED DCP.

Figure 4.5 DCP Test Apparatus of TRRL Model A2465

This test was carried out after every two passes of each of the rollers specified in Table 4.5. The TRRL computation method was used to determine the CBR of the compacted layer. Thus, $\text{Log}_{10}\,\text{CBR} = 2.48 - 1.057 \times \text{Log}_{10}\,X$, where X is the slope of the plotted Penetration / number of blows relationship. In each test the apparatus was mounted on the compacted bed. The hammer of the apparatus was then made to fall freely and the penetrations, after every five blows, were recorded (see Photo 9). The slopes of the plotted graph, X, were determined. The strengths of the compacted bed were then determined using the above relationship.

Photo 9 DCP Test in Progress after 6 passes 8,559kg/170mm

4.3.4 *Sampling of "Model Site Compacted Samples"*

The Model Site Compacted Samples were acquired by carefully loosening up the side-wall of the in-situ density holes made in the compacted beds. Broken gravel particles found in the face of the density hole walls were removed before loosening up the compacted soil for sampling. The samples were collected into sample bags and sent to the laboratory for Atterberg Limits tests and grading analysis.

The Model Site Raw Sample was acquired from the soil heaps dumped along the outer edge of the Test Site.

4.3.5 *Laboratory Tests for Model Site Samples*

Prior to testing, the samples were air -dried at room temperature. Each dried sample was then quartered with the aid of a riffle box to obtain 1000 g quantity for grading analysis. The material was sieved through the 0.425 mm BS test sieve before being tested for Atterberg Limit.

Both the wet sieving method and the hydrometer method, of BS 1377, Part 1 and Part 2 respectively, were used in the particle size distribution analysis for the soil samples. Compaction test was also performed on the "raw sample" from the model site to obtain the MDD and O.M.C.

4.4 Construction Site Compaction Studies

4.4.1 *Study Sites*

A total of five construction sites were identified and selected for the studies. The selection of a site was based solely upon a Contractor's willingness to assist in the studies. In brief, the distribution of the construction sites were as follows: Zone 1, one on-going road project site in the Northern Region; Zone 2, one on-going road project site in the Ashanti Region and one on-going bridge project site in the Brong-Ahafo Region, and again, another on-going road project site situated between the Western Region and the Brong-Ahafo Region; Zone 3, one on-going road project site in the Greater –Accra Region. In each case, a test site of length 100 m, as shown in Figure 4.6, was used for the studies. The width of the Test Site stretched between the centreline of the road to the outer edge of the traffic lane or the U-drain, depending upon the prevailing site conditions.

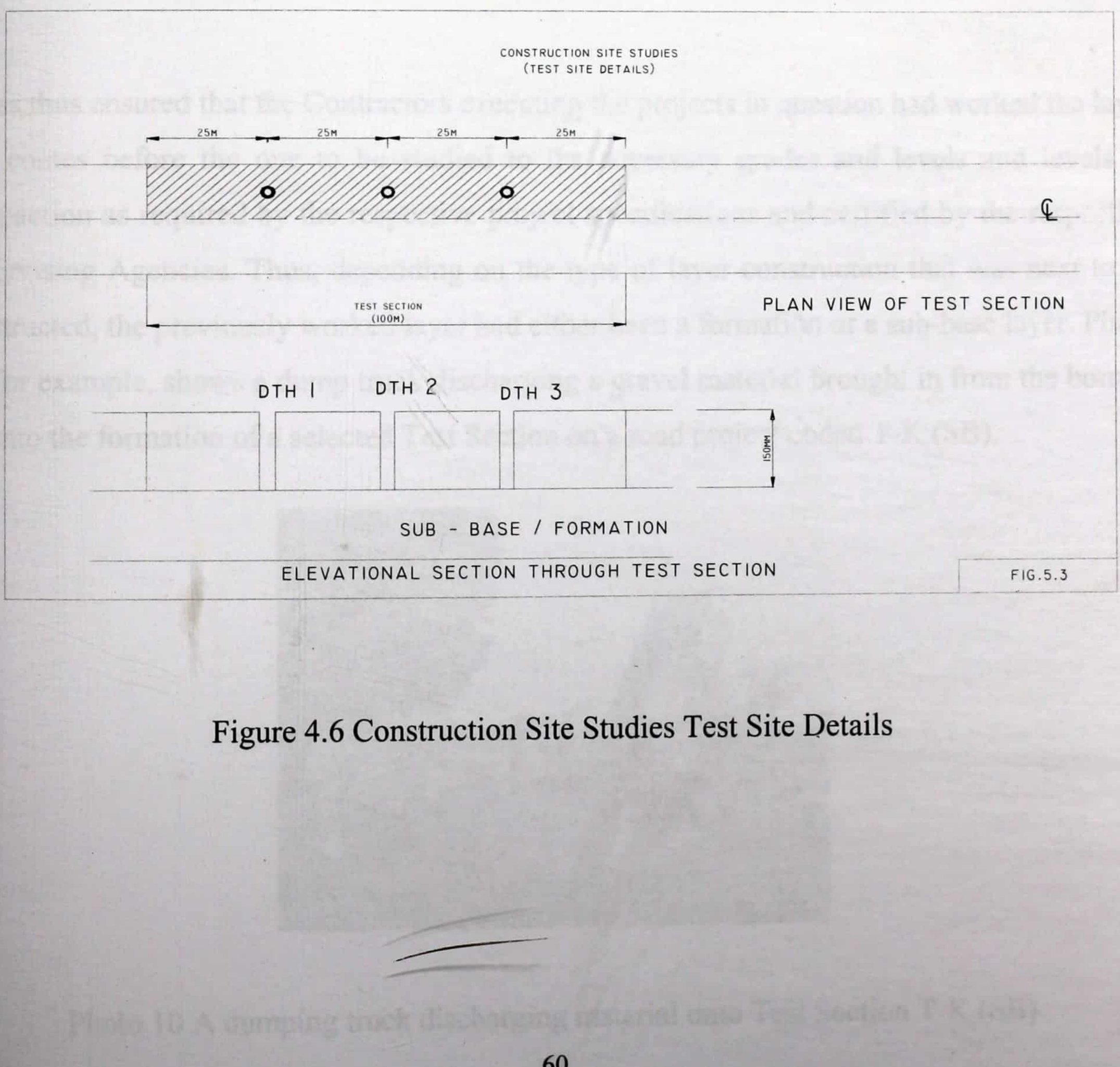


Figure 4.6 Construction Site Studies Test Site Details

4.4.2 *Test Site Preparations*

The pavement layers studied in the Construction Site Compaction Studies were either a sub-base layer or a base layer as shown in Table 4.5.

Table 4.5 Construction Project Sites used in the Studies

Zone	Project Code	Type of Materials	Compaction Plants Employed	
			Weight (Kg)	Type
1	T-K (B)	Base	17,500	Vibratory Roller
2	JZ-Y (SB)	Sub-base	11,400	Vibratory Roller
	GR (B)	Base	15,380 8,559	Vibratory Roller Static Roller
	A-N (SB)	Sub-base	15,250 14,515	Vibratory Roller Pneumatic Type Roller
3	AJ-AD (B)	Base	14,500	Vibratory Roller

It was thus ensured that the Contractors executing the projects in question had worked the layer that comes before the one to be studied to the necessary grades and levels and levels of compaction as required by the respective project specifications and certified by the respective Supervising Agencies. Thus, depending on the type of layer construction that was next to be constructed, the previously worked layer had either been a formation or a sub-base layer. Photo 10, for example, shows a dump truck discharging a gravel material brought in from the borrow pit unto the formation of a selected Test Section on a road project coded T-K (SB).

Photo 10 A dumping truck discharging material onto Test Section T-K (SB)

The natural soil material to be used for the next stage of the pavement construction works was then brought in from the borrow pit in trucks and dumped in heaps along the length of the selected Test Section. Sampling of the natural soil materials was done as shown in Photo 11 and the samples were designated "Field Raw Samples".

4.4.3 *Compaction in the Field*

The Contractor's Site Supervisor thereafter proceeded with the next stage of the construction works. This basically involved spreading of the natural soil material to the required grades and levels to form a loose bed as shown in Photo 12.

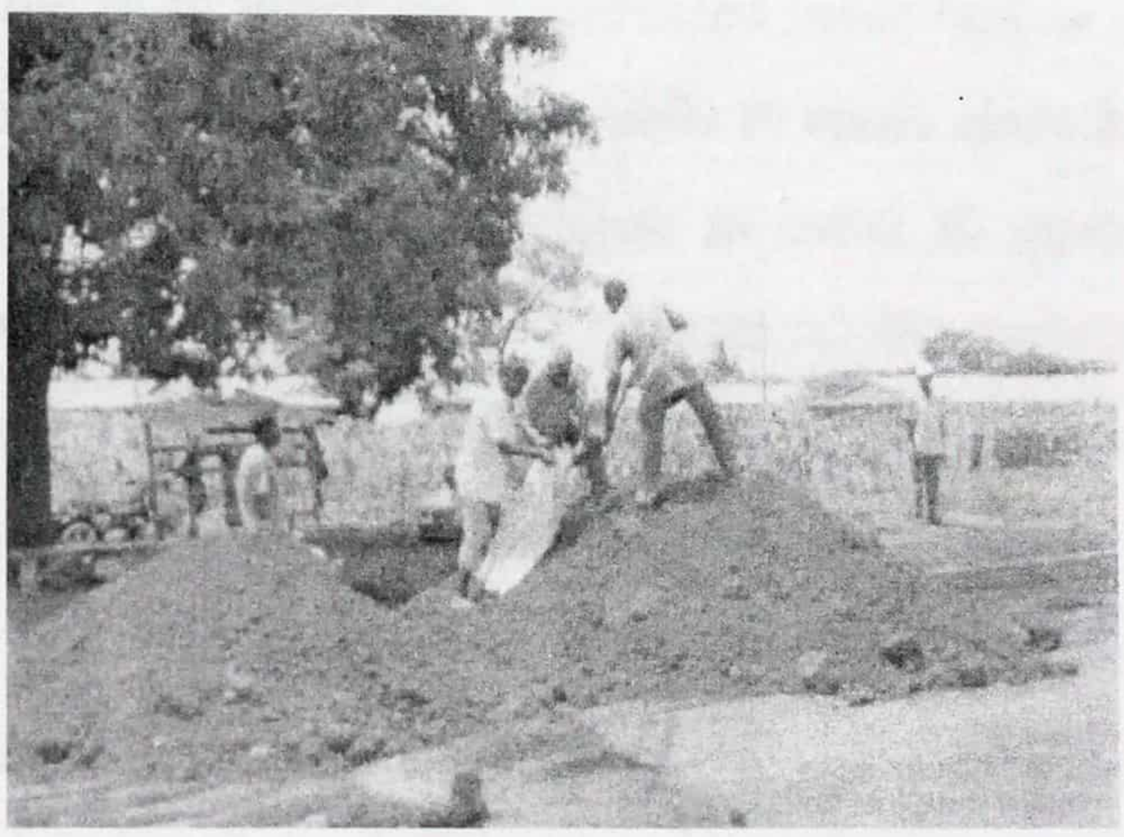


Photo 11 Sampling of "Raw Field Samples" within Test Section. T-K (SB)

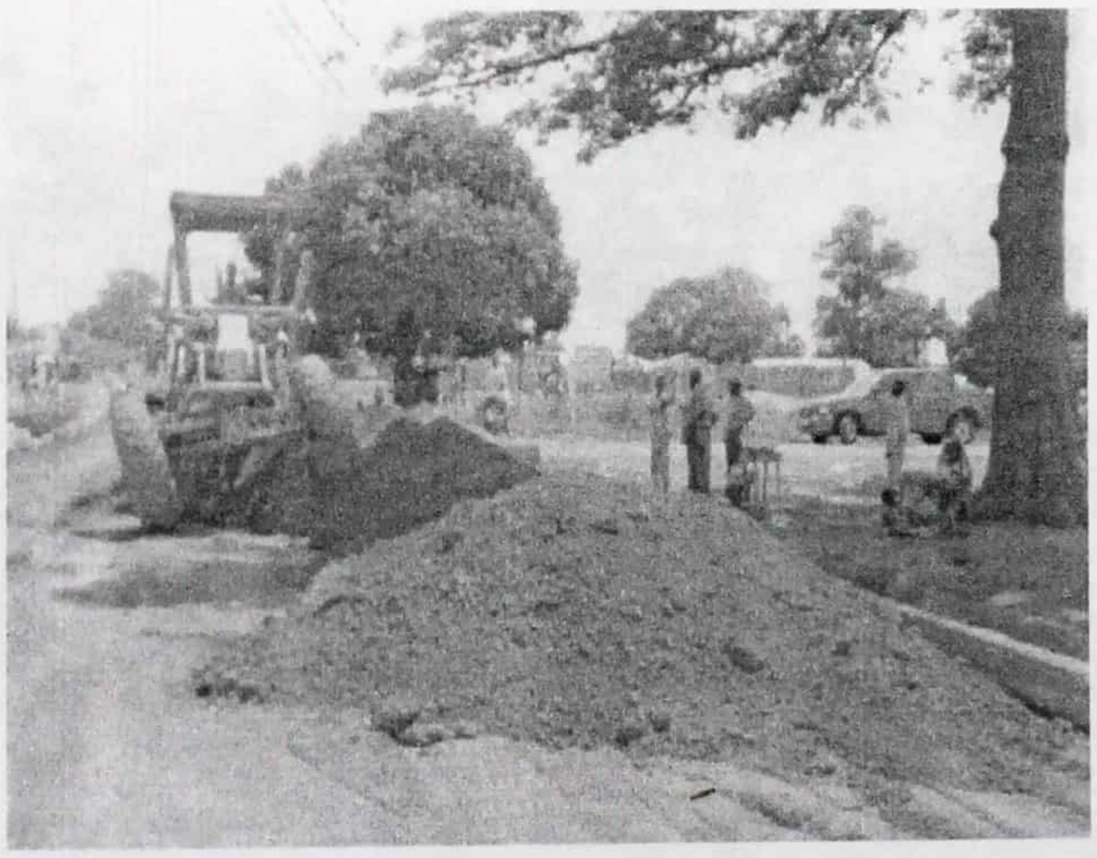


Photo 12 Spreading of sub-base material within Test Section. T-K (SB).

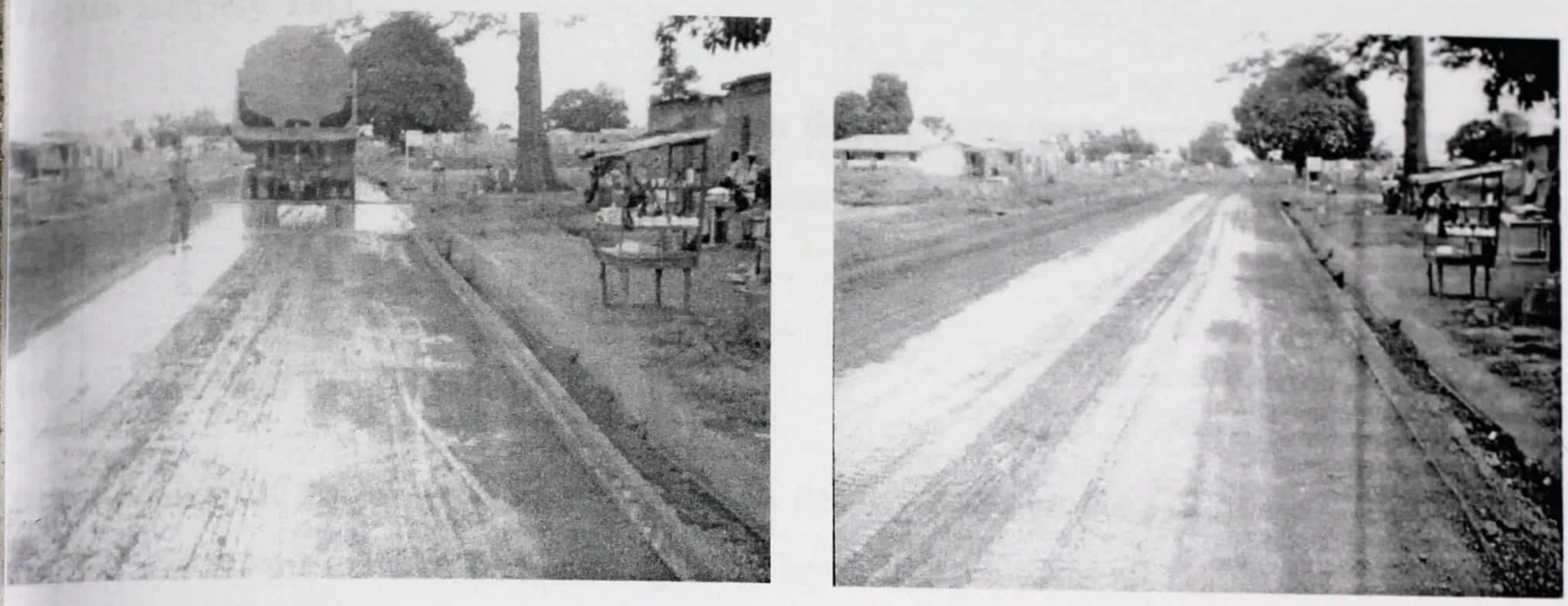


Photo 13 Watering of laid / spread out Field Raw Sample, in Test Section, T-K (SB)

A water bowser then came in to water the constructed loose bed as shown in Photo 13, thus enabling the moisture contents of the respective soils to come close to the optimum. A period of about three hours was then allowed to elapse in order to enable the water applied to penetrate into the soil material and also for the water on the surface of the layer to dry up sufficiently so that compaction would not be hindered. Compaction of the loose bed then began. The compaction process once started was continued until such time that the site supervisor would, from his field experience, judge that the layer had achieved the level of compaction desired by the project specification. The number of passes made by the compaction plant, in both the forward and backward directions, were observed and recorded. The weight or weights of the compaction plant or plants employed in the compaction process were noted.

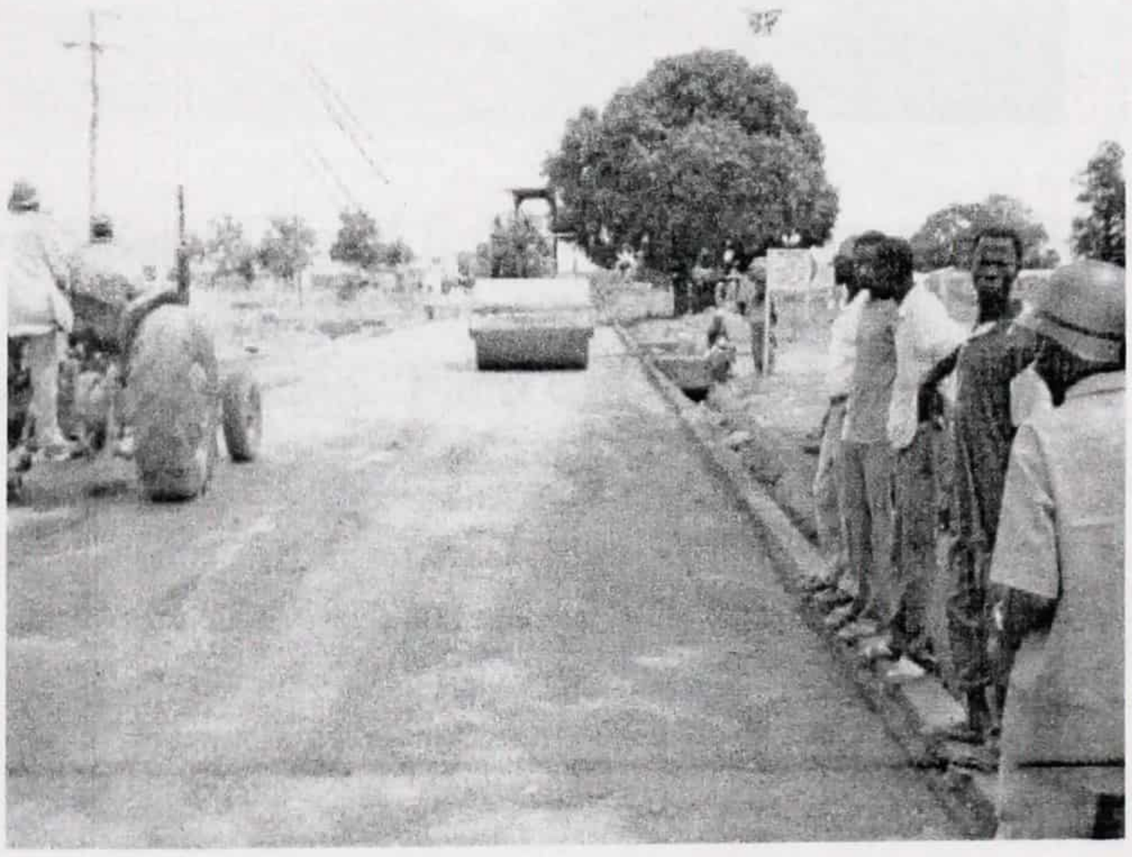


Photo 14 A typical field compaction process in progress; T-K (SB).

In-situ Density Test

At the end of the compaction process, in-situ density tests were carried out to determine the actual level of compaction achieved. Testing was carried out at intervals of 25 m along the Test Section.

4.4.4 *Sampling of Compacted Materials*

At a distance of about one metre from each density hole, an area of about 1 m x 1 m was marked out on the surface of the compacted layer and the material within the area excavated with a pickaxe. The excavation process was continued until the layer below the compacted layer was encountered. The compacted material was thus obtained in bigger lumps as shown in Photo 15. It must be noted that materials close to the excavated edges of these lumps were carefully loosened up using the hand and discarded.

Photo 15 Sampling of field compacted material T-K (SB)

The excavated material was designated "Field Compacted Samples".

4.4.5 *Laboratory Testing*

Sample Preparation

Both the Field Raw Sample and the Field Compacted Samples were air dried at room temperature. The Field Compacted Samples were carefully loosened up with the hand and rubber mallet in order to avoid artificial breakage of the gravel size particles.

Each dried sample was then quartered, with the aid of a riffle box, to obtain 2000 kg to 3000 kg weight of test samples for grading analysis. Again, sufficient material was sieved through the 0.425 mm BS test sieve to obtain about 400 g weight of test sample, from each dried sample, for Atterberg Limit test.

4.4.5.1 Index Property Tests

The testing procedures as discussed in previous sections were repeated here for the Field Raw Sample and each of the Field Compacted Samples.

5. DISCUSSION OF TEST RESULTS

5.1 General

5.1.1 *The Consistency of the testing procedure*

In order to examine the level of accuracy in the testing method used in the particle size distribution, two grading tests was carried out on the same soil material for some of the 10 soil samples investigated. Figure 5.1 shows a typical plot obtained for one of the said soil materials. The plot indicates that there is insignificant variation in the two tests. This suggests that there is a high level of consistency in the testing procedure used.

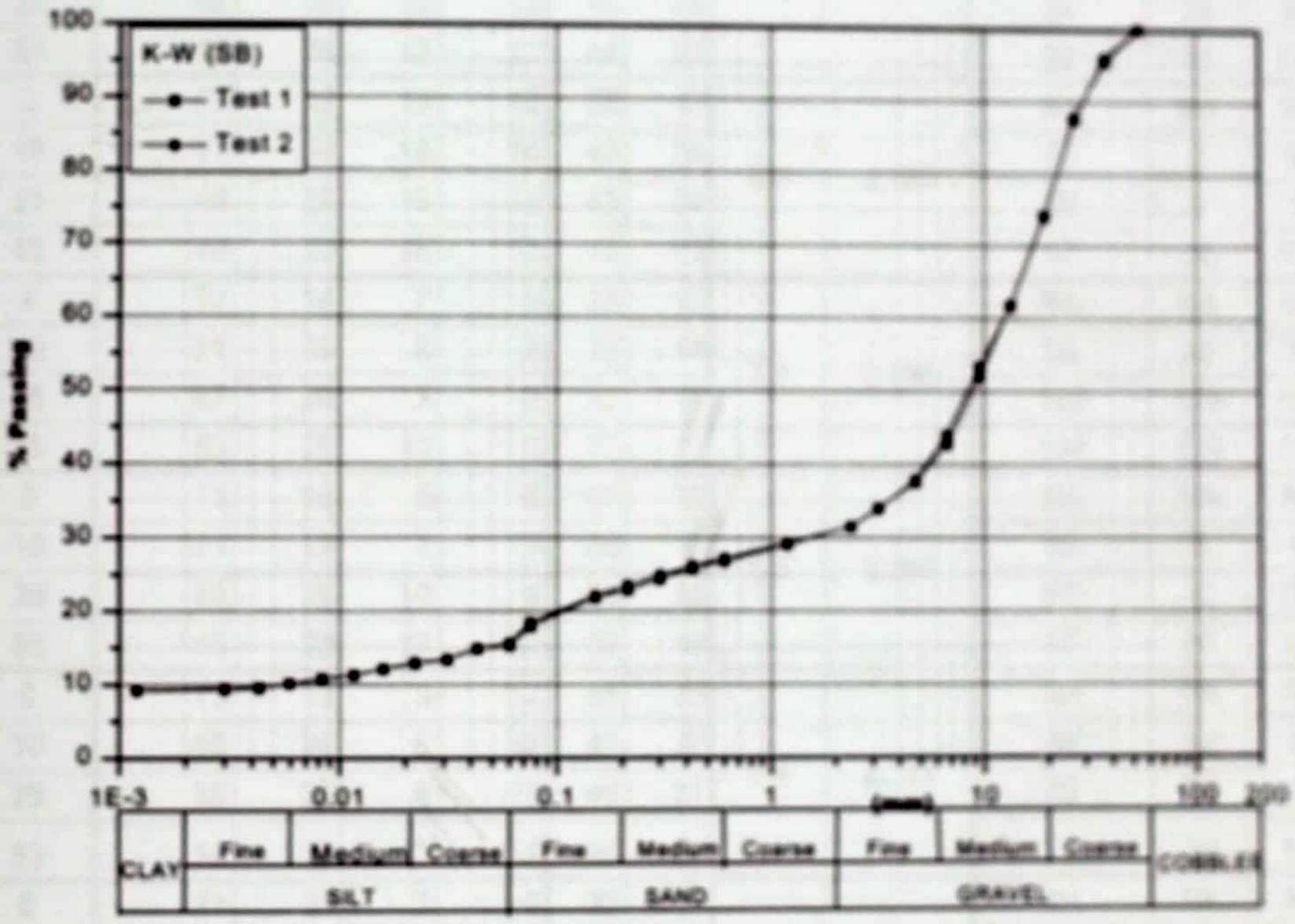


Figure 5.1 Consistency of test results.

5.2 Laboratory Compaction Studies

A summary of the laboratory test results on the samples from the 10 sites is shown in Table 5.1. The test results obtained have been discussed in detail under the following headings:

Table 5.1 Summary of Results for Laboratory Compaction

Zone	Project Code	Blows	Grading				Plasticity		Compaction		CBR				AASHTO Class.
							LL	PI	OMC	MDD	Rel. Comp.***	S*	U*	Swell	
			Gravel	Sand	Silt	Clay	%	%	(%)	Mg/m^3	%	%	%	mm	
1	T-K (B)	0	67	20	9	4	29	9	8.8	2.307	NA	NA	NA	NA	A-2-4
		10	60	27	10	3	27	9			93	34	56	0.3	
		25	54	31	12	3	26	8			98	103	128	0.15	
		55	50	32	13	5	27	9			101	94	237	0.15	
	T-K (SB)	0	69	18	7	6	35	12	8.8	2.333	NA	NA	NA	NA	A-2-6
		10	66	19	8	7	35	16			88	36	62	0.45	
		25	59	21	12	8	34	14			94	121	113	0.45	
		55	54	26	11	9	31	13			97	160	142	0.15	
2	JZ-Y (SB)	0	69	17	8	6	31	15	9.2	2.23	NA	NA	NA	NA	A-2-6
		10	66	19	9	6	37	21			90	38	55	0.45	
		25	61	23	9	7	35	19			96	64	102	0.15	
		55	59	23	11	7	34	17			100	77	82	0.15	
	K-A (SB)	0	59	16	15	10	51	25	7.5	2.298	NA	NA	NA	NA	A-2-7
		10	56	16	17	11	44	23			87	2	38	0.3	
		25	52	19	17	12	46	23			94	25	98	0.3	
		55	46	24	18	12	44	23			98	44	174	0.15	
	L-BP (SB)	0	61	12	15	12	36	17	8.8	2.188	NA	NA	NA	NA	A-2-6
		10	51	20	15	14	43	24			82	2	36	0.75	
		25	49	22	15	14	43	24			90	8	76	1.05	
		55	49	20	16	15	42	23			97	50	170	0.15	
	GR (B)	0	77	14	7	2	33	15	7.9	2.194	NA	NA	NA	NA	A-2-6
		10	71	19	8	2	32	14			95	42	49	0.45	
		25	67	24	7	2	32	14			100	124	136	0.45	
		55	63	25	10	2	32	15			104	129	110	0.15	
	A-N (SB)	0	71	18	5	6	40	19	6.6	2.264	NA	NA	NA	NA	A-2-6
		10	71	15	7	7	38	18			86	5	48	4.8	
		25	56	25	10	9	38	18			93	40	109	-0.15	
		55	48	28	12	12	37	19			97	88	129	-0.15	
	JB (B)	0	73	13	3	11	56	33	7.4	2.174	NA	NA	NA	NA	A-2-7
		10	59	24	5	12	47	27			89	12	24	0.15	
		25	55	26	6	13	46	27			95	71	72	0.3	
		55	54	23	7	16	45	26			100	59	118	0.6	
3	AJ-AD (SB)	0	71	20	3	6	32	17	7.2	2.193	NA	NA	NA	NA	A-2-6
		10	52	37	6	5	29	14			86	32	43	0.15	
		25	41	47	5	7	29	14			98	97	115	0.45	
		55	38	47	7	8	31	15			100	124	190	0.15	
	K-W (SB)	0	59	20	9	12	45	24	11	2.131	NA	NA	NA	NA	A-2-7
		10	48	27	11	14	38	23			91	21	23	0.3	
		25	40	31	14	15	36	19			96	30	46	0.6	
		55	40	30	14	16	36	19			97	33	56	0.45	

NOTES:

*Soaked CBR

** Unsoaked CBR

*** Level of Compaction achieved during CBR test.

- Effect of Laboratory Compaction on Particle Size Distribution.
- Effect of Laboratory Compaction on Plasticity of the Fines.

- Effect of Laboratory Compaction on Strength.

5.2.1 *Effect of Laboratory Compaction on Particle Size Distribution*

Figure A 1-A.10 of Appendix A, show the plotted grading curves of the various soil samples tested under laboratory compaction studies. The grading curves show increase in particle breakdown with increasing specific energy or compactive effort from 10 blows to 55 blows for all the soil samples tested. In most cases the gravel content decreased as the number of blows increased. In order to examine the progress of particle breakage during laboratory compaction, the gravel content of the soil materials after 10, 25, and 55 blows were extracted from Table 5.1 and the percentage loss per blow for each of the three levels of compaction calculated. The results are shown in Table 5.2 and plotted in Figure 5.2.

Table 5.2 Effect of laboratory Compaction on Particle Breakdown

Zone	Project Code	Blows Applied		% Loss in Gravel Content	% Loss/Blow
		Actual No.	Cumm. No.		
1	T-K (B)	10	10	7	0.70
		15	25	6	0.40
		30	55	4	0.13
		Totals		17	
	T-K (SB)	10	10	3	0.30
		15	25	7	0.47
		30	55	5	0.17
		Totals		15	
2	JZ-Y (SB)	10	10	3	0.30
		15	25	5	0.33
		30	55	2	0.07
		Totals		10	
	K-A (SB)	10	10	3	0.30
		15	25	4	0.27
		30	55	6	0.20
		Totals		13	
	L-BP (SB)	10	10	10	1.00
		15	25	2	0.13
		30	55	0	-
		Totals		12	
	GR (B)	10	10	6	0.60
		15	25	4	0.27
		30	55	4	0.13
		Totals		14	
	A-N (SB)	10	10	0	-
		15	25	15	1.00
		30	55	8	0.27
		55		23	
	JB (B)	10	10	14	1.40
		15	25	4	0.27
		30	55	1	0.03
		55		19	
3	AJ-AD (SB)	10	10	19	1.90
		15	25	11	0.73
		30	55	3	0.10
		55		14	
	K-W (SB)	10	10	11	1.10
		15	25	8	0.53
		30	55	0	-
		55		19	

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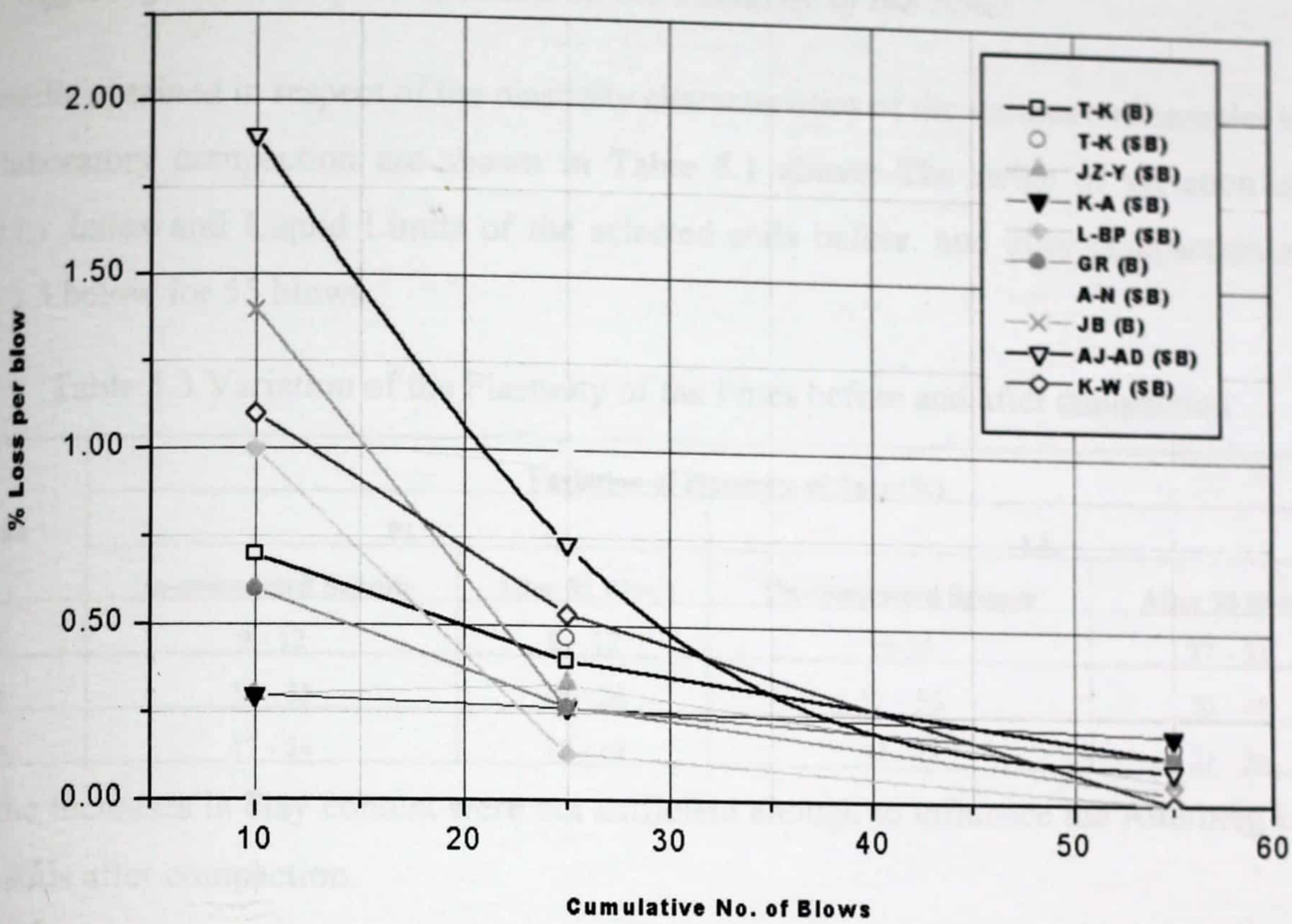

Figure 5.2 Percentage Loss of Gravel per Blow during laboratory compaction

The figure shows, that the rate of particle breakdown was higher at the initial stages of compaction, but decreases with further compaction. This trend, however, becomes lower towards the latter stages of compaction. Compared to the other samples, T-K (SB), K-A (SB) and A-N (SB) did not show significant particle breakage at the initial stages of compaction, nevertheless they did show decreasing rate as compaction progressed. It must also be noted that the % loss / blow in gravel content stated in Table 5.2 was in actual fact the average rate at which the gravel content had depreciated at the respective order of 10, 15 and 30 effective or actual blows applied. This behaviour of the soil materials could be explained as follows. Since the soil particles are loosely packed at the initial stages of compaction, impact loads applied on them are well concentrated over that small portion of the soil material which comes into direct contact with the load. This apparently leads to higher particle breakdown since the gravel particles suffer the full impact effect of the applied load. However, as the process of compaction progresses the soil material starts densifying into a unified mass through the inter-locking of the soil particles. This enables the soil material to behave as a single mass in resisting further impact load effects, hence the reduced level of particle breakdown.

5.2.2 *Effect of Laboratory Compaction on the Plasticity of the Fines*

The results obtained in respect of the plasticity characteristics of the various soil samples tested after laboratory compaction are shown in Table 5.1 above. The range of variation of the Plasticity Index and Liquid Limits of the selected soils before, and after compaction are in Table 5.3 below for 55 blows.

Table 5.3 Variation of the Plasticity of the Fines before and after compaction

Zone	Variation of Plasticity of fines (%)			
	PI		LL	
	Un-compacted Sample	After 55 Blows	Un-compacted Sample	After 55 Blows
1	9 - 12	9 – 13	29-35	27 – 31
2	15 - 33	15 – 26	31 – 56	32 - 45
3	17 - 24	15 - 19	32 - 45	31 - 36

Thus the increases in clay content were not sufficient enough to influence the Atterberg Limits of the soils after compaction.

5.2.3 *Compaction characteristics of soils*

Figures 5.3 –5.5 show the compaction characteristics of the various soils studied.

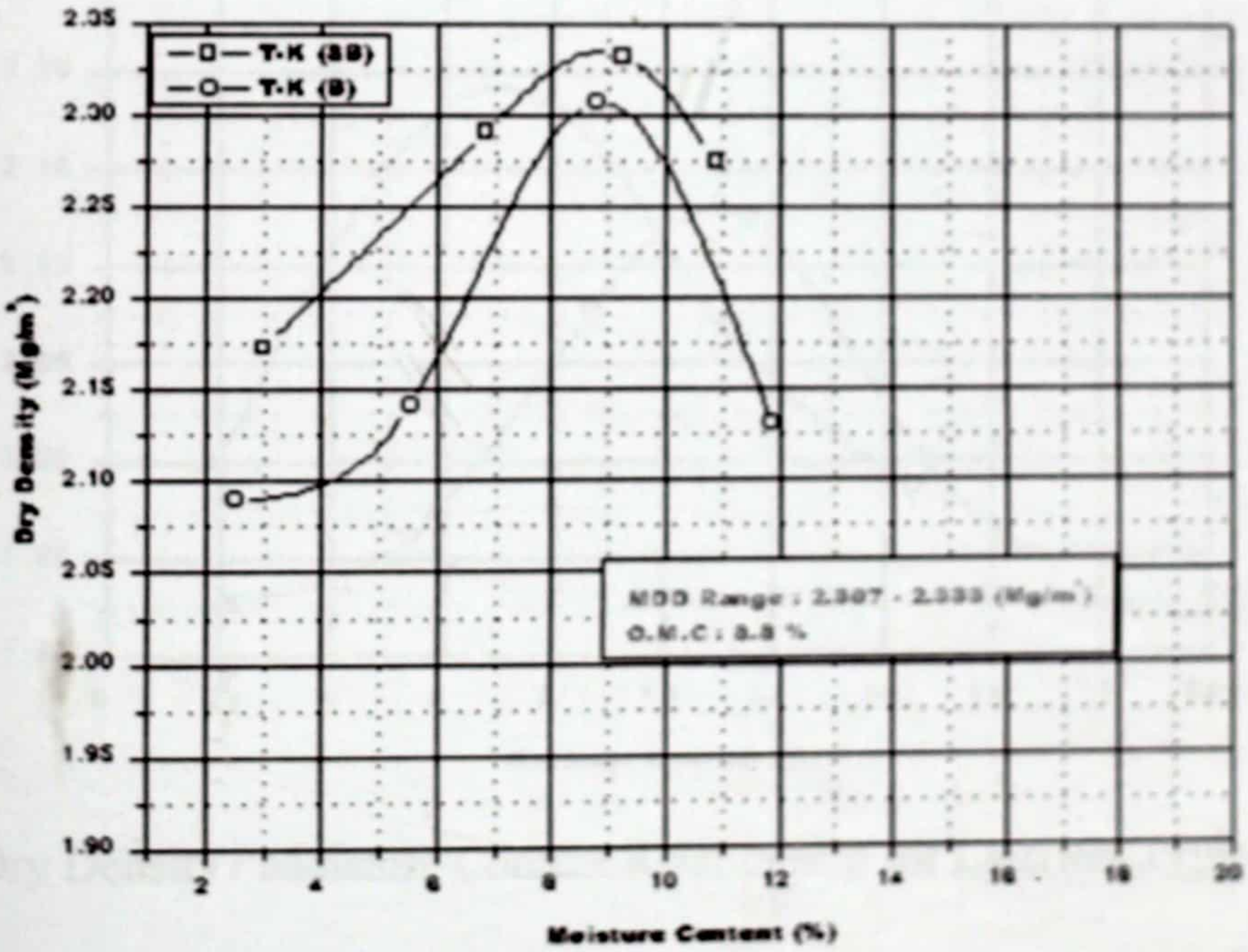

Figure 5.3 Dry Density / Moisture Content Relationship for Laterites Typical of Zone 1

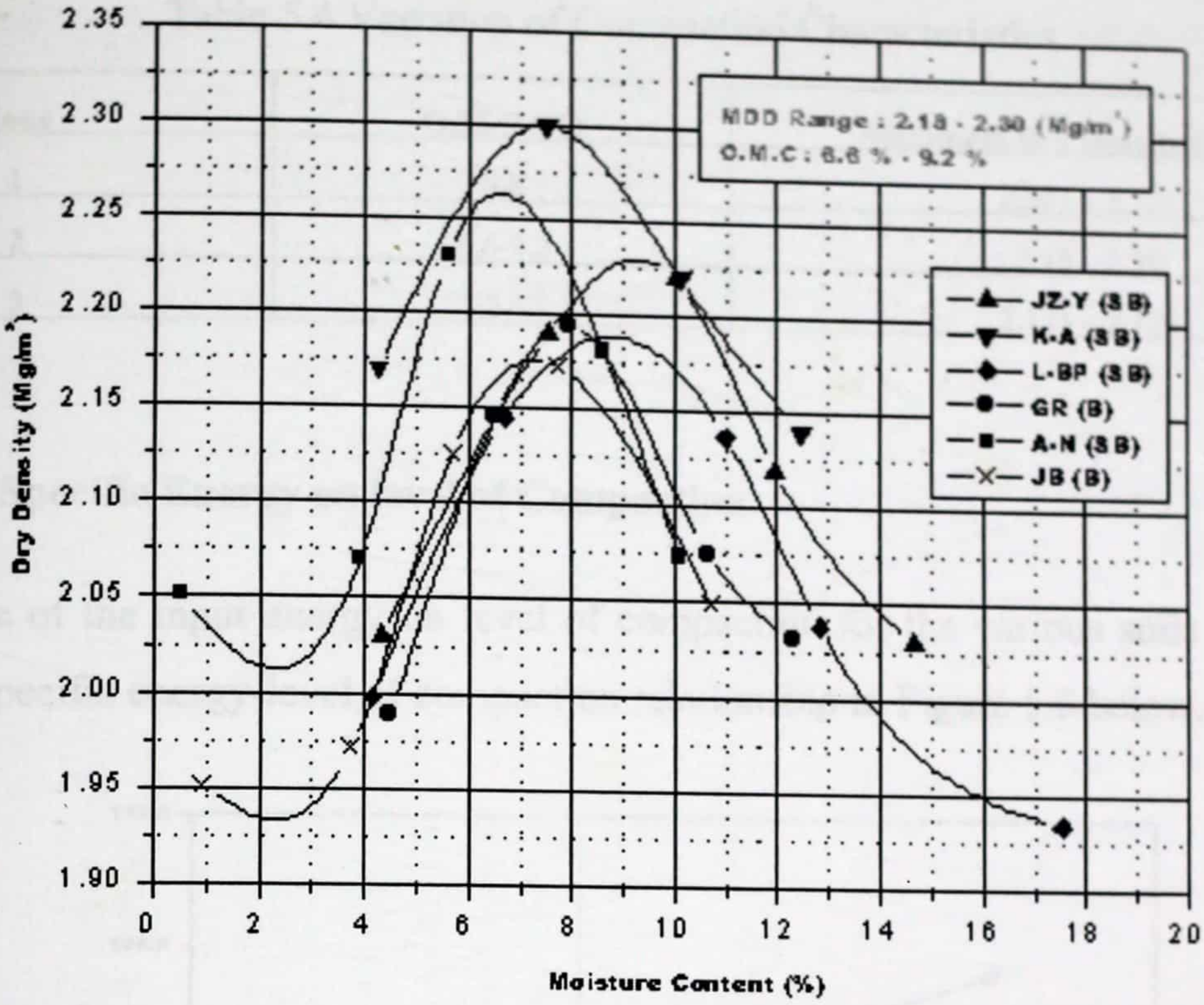

Figure 5.4 Dry Density / Moisture Content Relationship for Laterites Typical of Zone 2

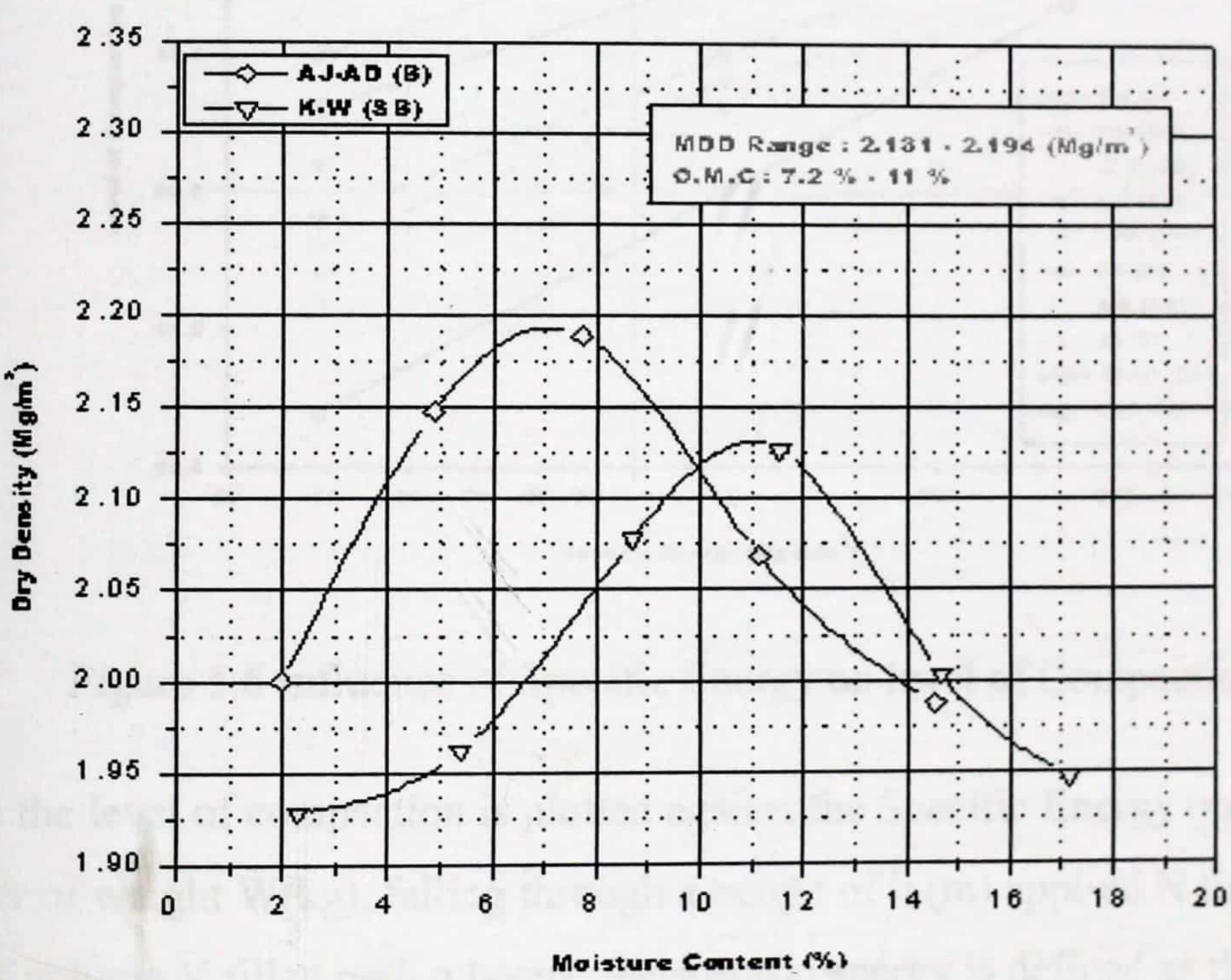

Figure 5.5 Dry Density / Moisture Content Relationship for Laterites Typical of Zone 3

The OMC and MDD values have been tabulated in Table 5.4. It is observed that soils of Zone 1 have very high maximum dry densities whereas soils of Zone 3 have lower maximum dry densities.

Table 5.4 Variation of Compaction Characteristics

Zone	O.M.C (%)	Maximum Dry Density (Mg/m^3)
1	8.8	2.307 – 2.333
2	6.6-9.2	2.18 – 2.30
3	7.2-11	2.131 – 2.194

Influence of Specific Energy on level of Compaction

The influence of the input energy on level of compaction for the various soils are examined through the specific energy-level of compaction relationship in Figure 5.6 below.

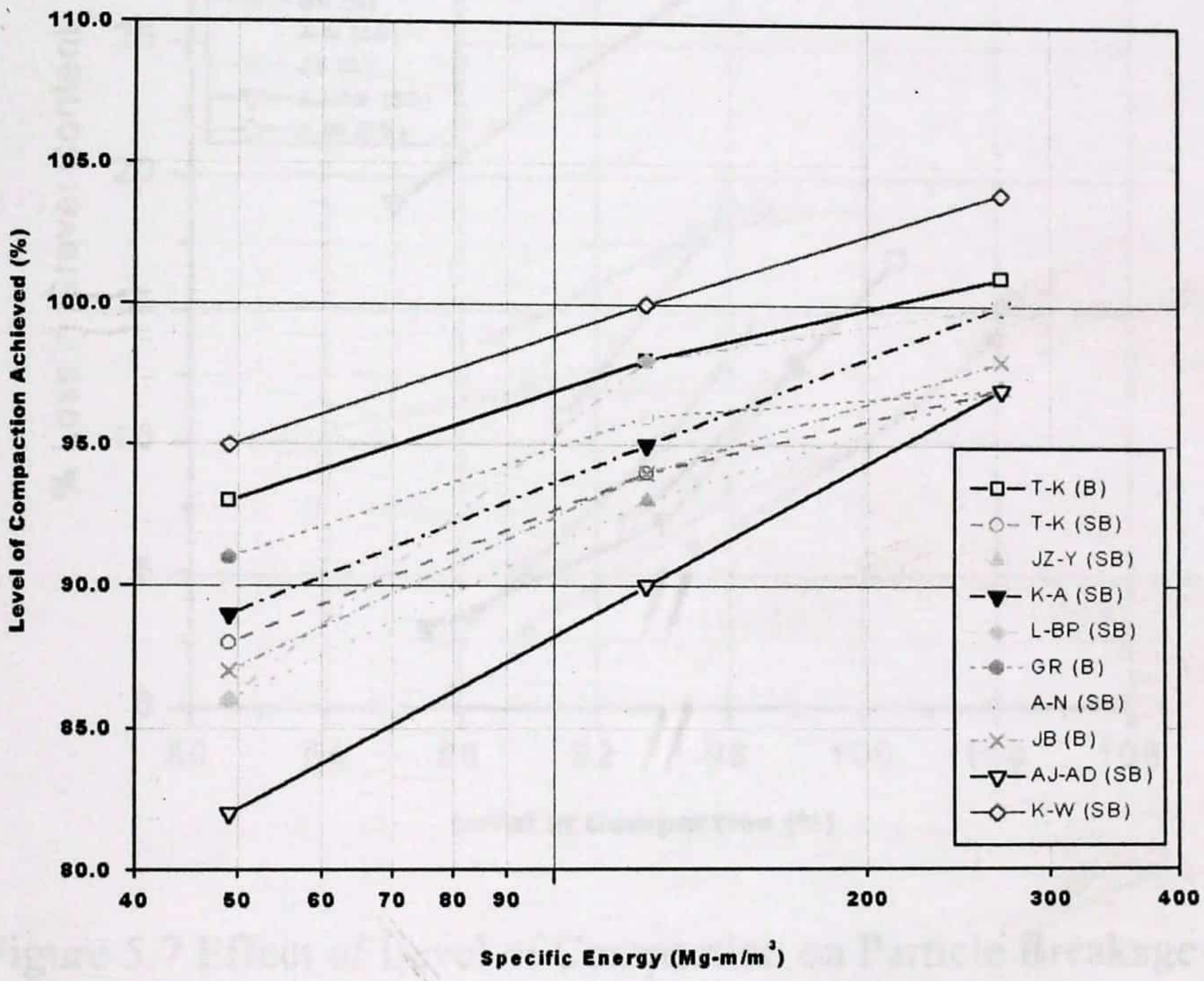

Figure 5.6 Influence of Specific Energy on level of Compaction

In the figure the level of compaction is plotted against the Specific Energy on a semi-log scale. For a rammer of weight W(kg), falling through a height of h (m) applied N times per layer and the mould of volume V filled with n layers, the specific energy is defined as the

$$E = \frac{nNhW}{V}$$

The specific energy was computed for 10 blows, 25 blows and 55 blows. The figure shows that the level of compaction increases with increasing specific energy. Furthermore, with the possible exception of T-K (SB), L-BP (SB) and GR (B), the increase appear to be linear for

most of the soil samples, but the rate of increase is different. The figure further shows a wide range of variation of level of compaction at lower specific energy as against a narrow range of variation of level of compaction at higher specific energy.

In order to examine the cause of the rather large variation of level of compaction at lower specific energy, the effect of level of compaction on particle breakage was assessed. The results obtained were plotted in Figure 5.7.

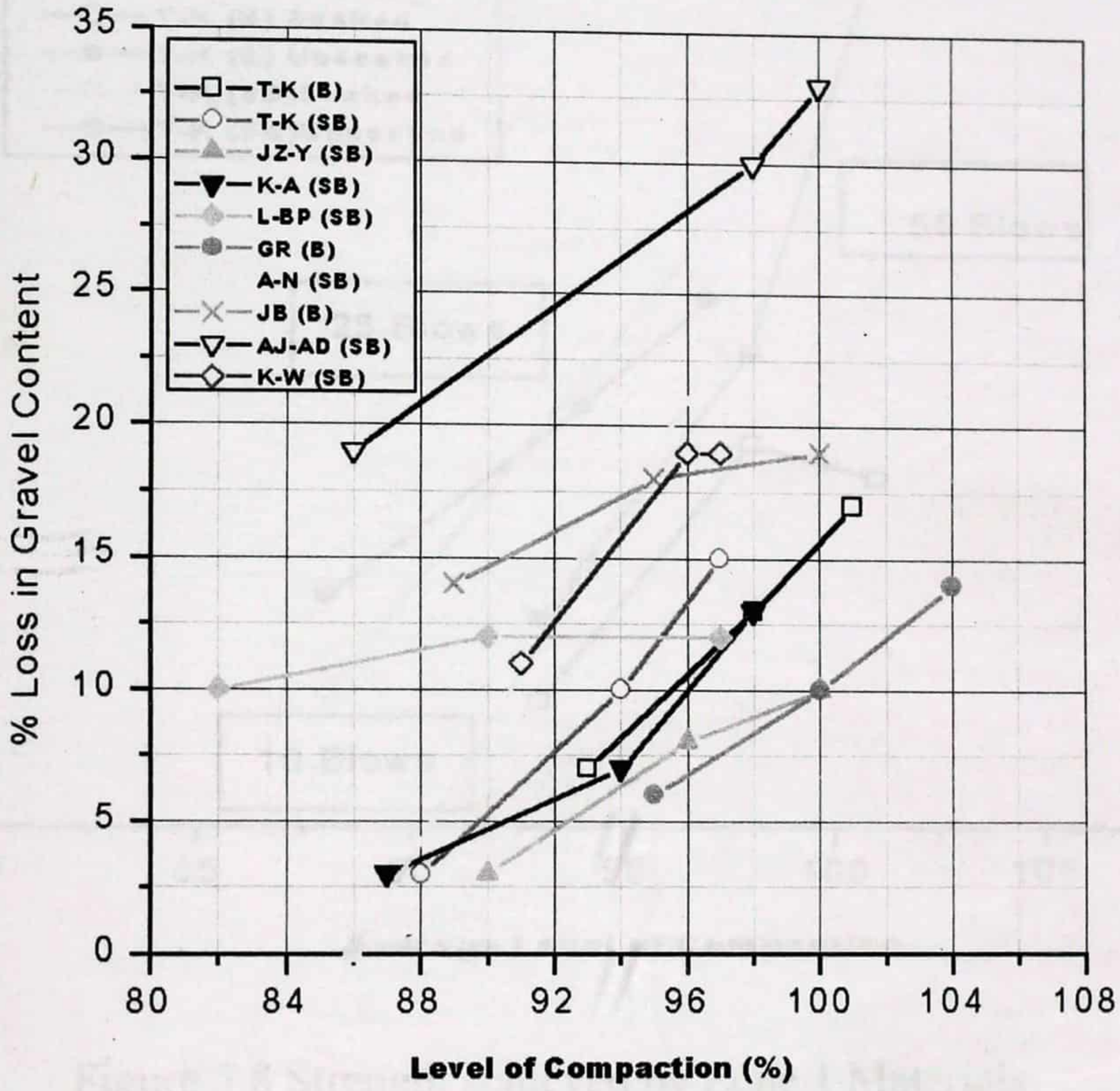

Figure 5.7 Effect of Level of Compaction on Particle Breakage

The figure shows that at increasing levels of compaction, the cumulative percentage loss in gravel contents of a soil are likely to be higher.

5.2.4 *Strength of Compacted Soil Samples*

The test results obtained in respect of the strength of the compacted soil samples as defined by the CBR have been summarised in Table 5.1, for both soaked and unsoaked conditions. Figures 5.8 to 5.11 show graphically the strength development pattern for both soaked and unsoaked conditions of the various soils studied. The figures show a general trend of the unsoaked CBR values being higher than their corresponding soaked values. However, sample GR (B) had a soaked CBR value being higher than its corresponding unsoaked CBR value for

55 blow compaction. A repeat test yielded the same result. Thus this peculiar behaviour exhibited by the unsoaked samples could be attributed to the effects of softening caused by the excessive remoulding of the soil during compaction. Thus the more flocculent structure of the soil is remoulded into a dispersed condition, during compaction, where the equilibrium of forces between particles is disturbed, and hence made softer.

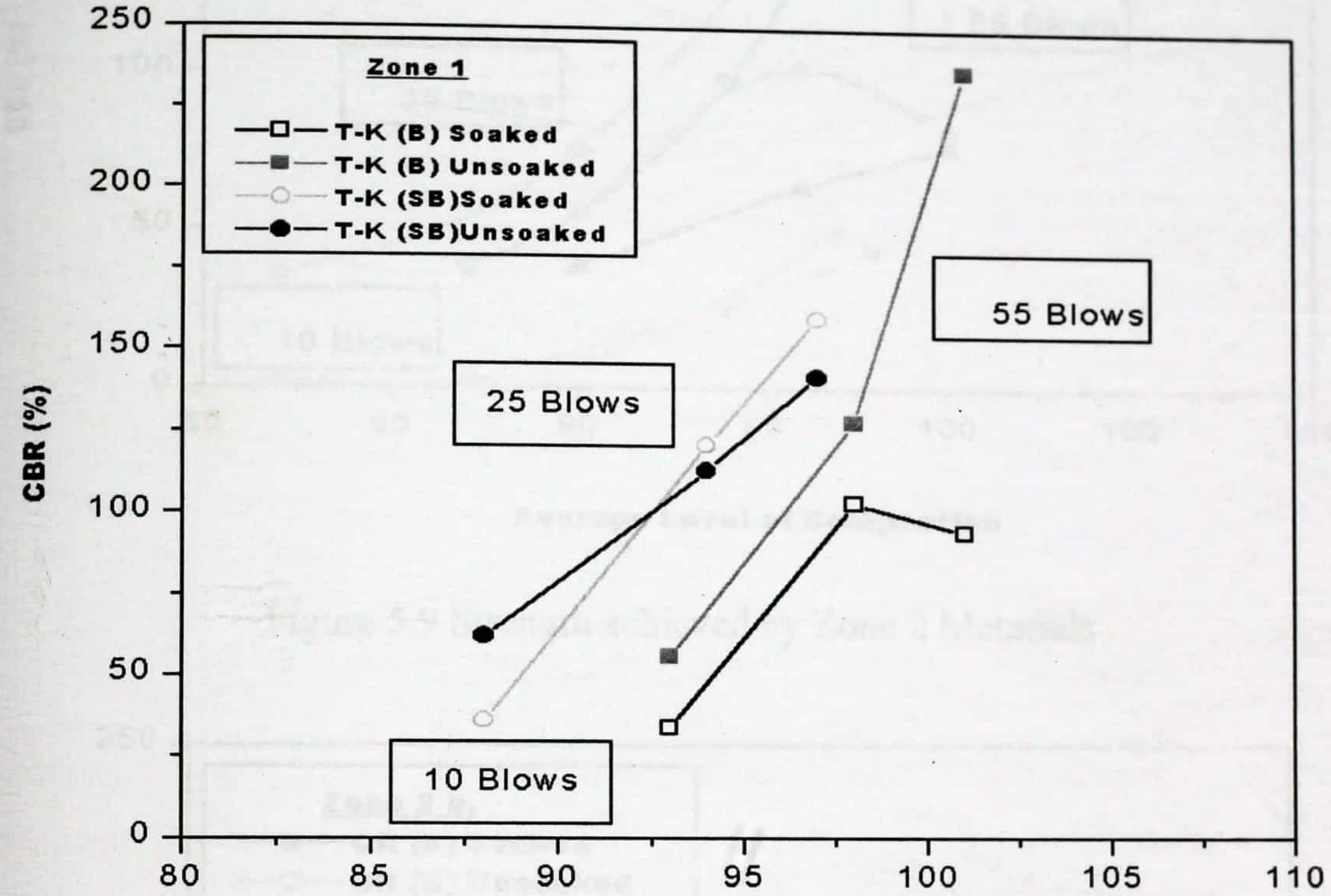

Figure 5.8 Strength achieved by Zone 1 Materials

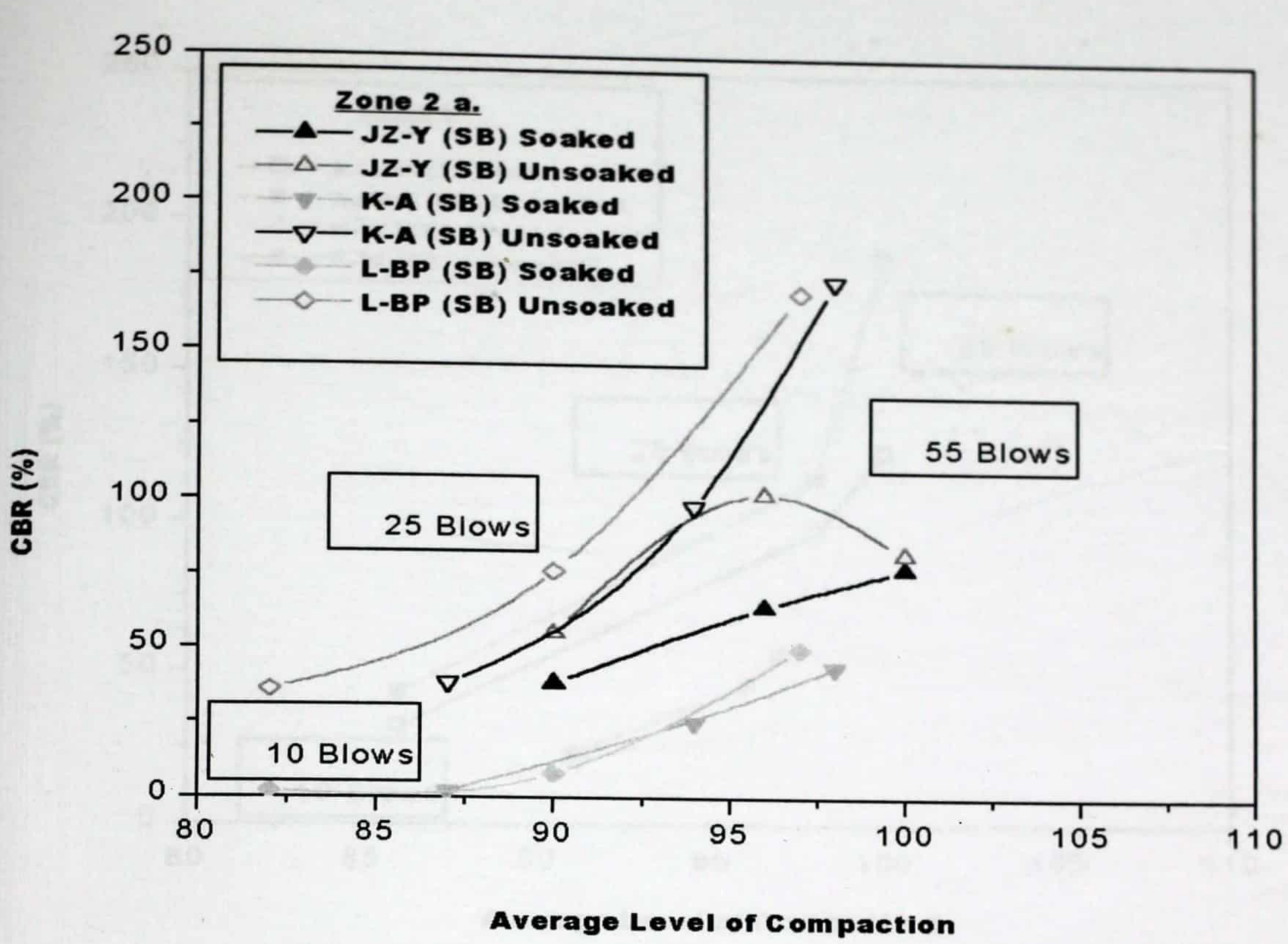

Figure 5.9 Strength achieved by Zone 2 Materials

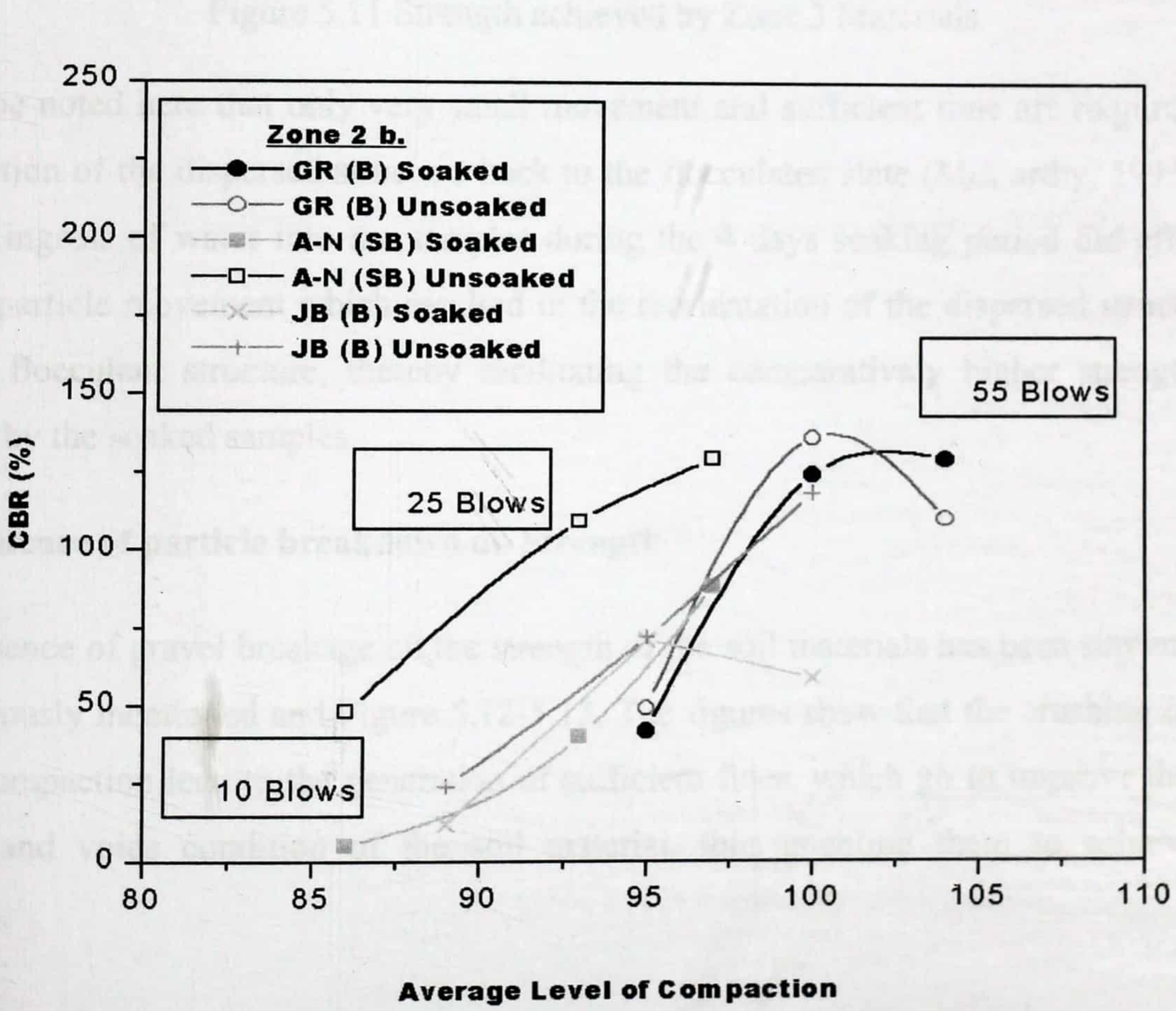

Figure 5.10 Strength achieved by Zone 2 Materials (Continuation)

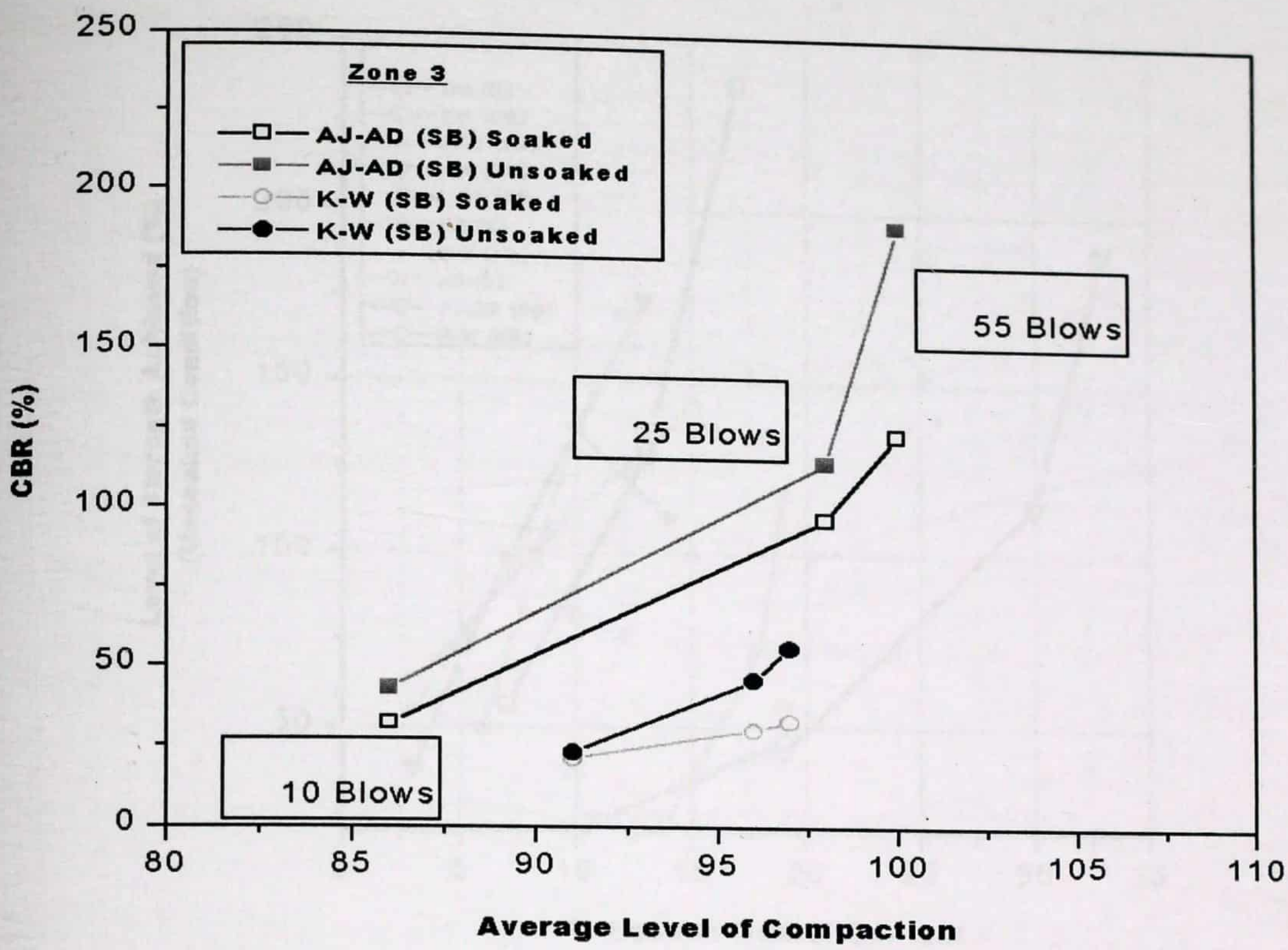

Figure 5.11 Strength achieved by Zone 3 Materials

It must be noted here that only very small movement and sufficient time are required for the reorientation of the dispersed structure back to the flocculated state (McCarthy, 1993). Thus, the 1 % ingress of water into the samples during the 4 days soaking period did effect some level of particle movement which resulted in the reorientation of the dispersed structure back into the flocculent structure, thereby facilitating the comparatively higher strength values depicted by the soaked samples.

The Influence of particle breakdown on Strength

The influence of gravel breakage on the strength of the soil materials has been shown in Table 5.1 previously mentioned and Figure 5.12-5.13. The figures show that the crushing of gravels during compaction lead to the generation of sufficient fines, which go to improve the general grading and voids condition of the soil material, thus enabling them to achieve higher strengths.

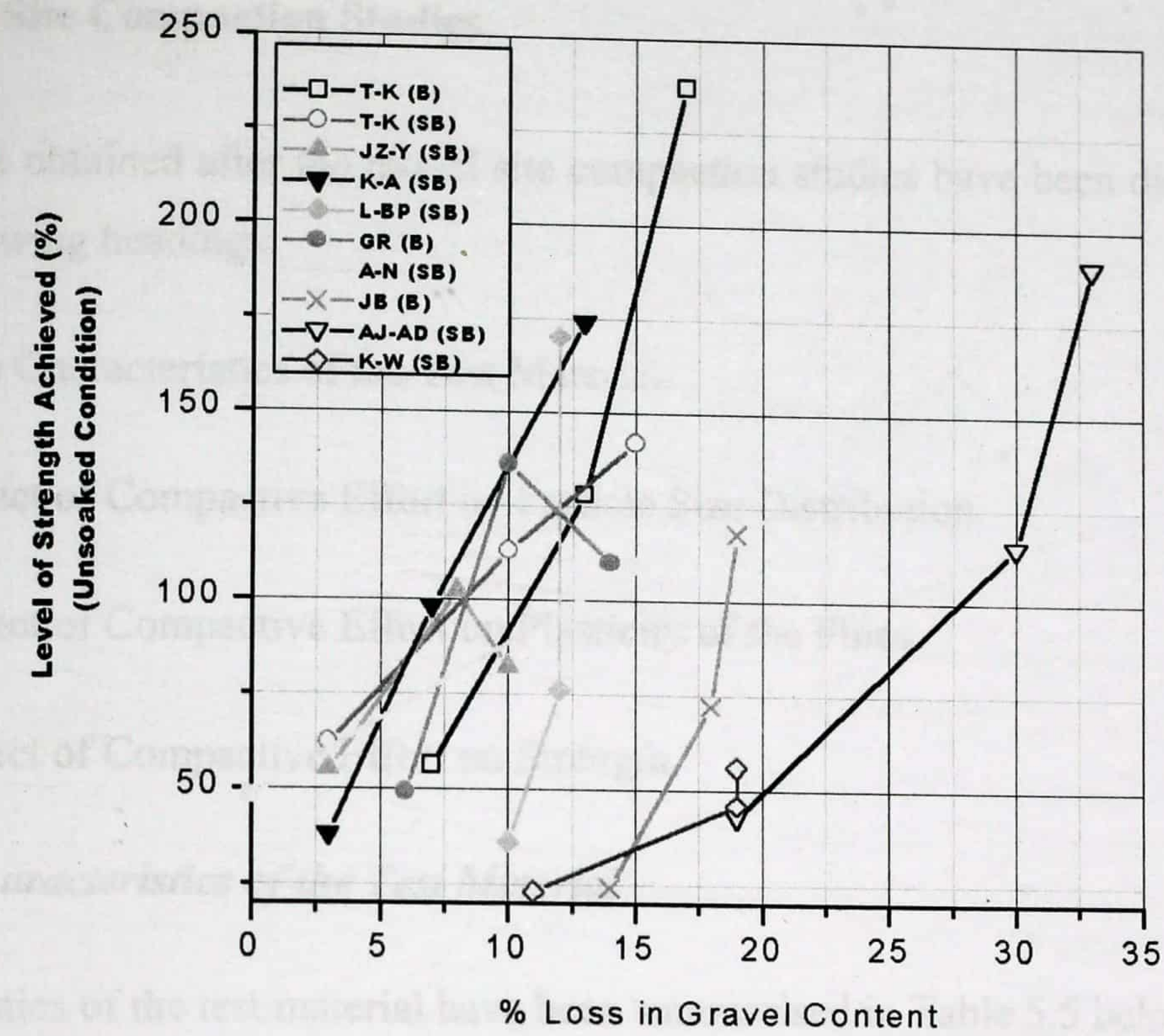

Figure 5.12 Influence of Particle Breakage on Strength (Unsoaked Condition)

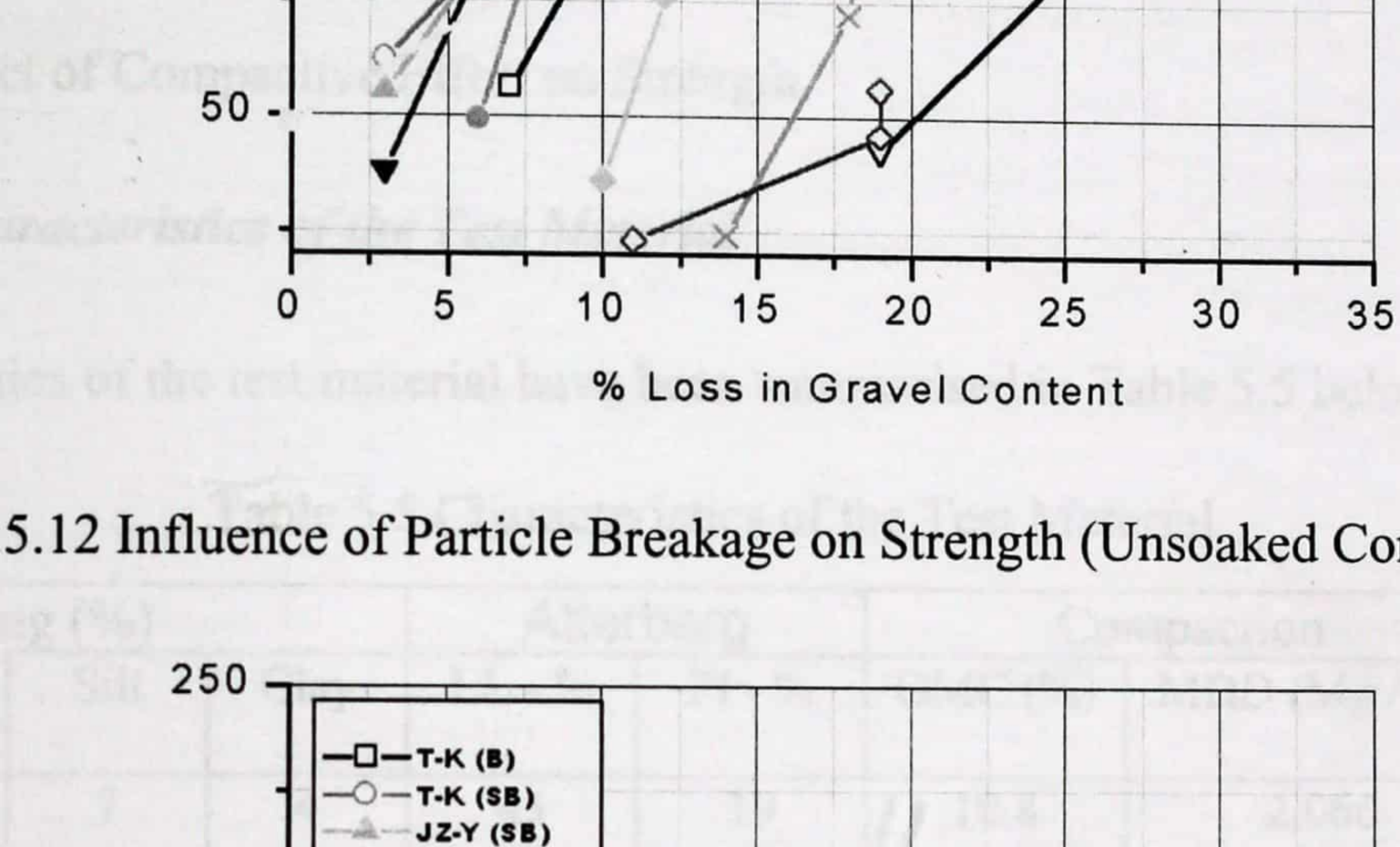

Figure 5.13 Influence of Particle Breakage on Strength (Soaked Condition)

5.3 Model Site Compaction Studies

The test results obtained after the model site compaction studies have been discussed in detail under the following headings:

- The Characteristics of the Test Material
- Effect of Compactive Effort on Particle Size Distribution.
- Effect of Compactive Effort on Plasticity of the Fines.
- Effect of Compactive Effort on Strength.

5.3.1 *The Characteristics of the Test Material*

The characteristics of the test material have been summarised in Table 5.5 below.

Table 5.5 Characteristics of the Test Material

Grading (%)				Atterberg		Compaction		CBR
Gravel	Sand	Silt	Clay	LL - %	PI - %	OMC (%)	MDD (Mg / m^3)	at 95 % MDD (%)
77	12	7	4	45	19	10.8	2.066	82

5.3.2 *Effect of Compactive Effort on Particle Size Distribution*

Figures 5.14- 5.18, show some of the plotted grading curves for the soil materials after field compaction using various compaction plants and three levels of loose lifts. The plots show that particle breakdown occurred with increasing number of roller passes on all the three loose lifts of 120 mm, 170 mm and 220 mm, using the 15,380 kg vibratory roller through it. The break down was marginal when the 8,559 kg and the 825 kg rollers were used. For example the loss in gravel content, for the 15,380 kg vibratory, was observed to be 3 %, 5 % and 7 % after the respective passes of 2, 4, and 6, in the case of a 120 mm loose lift bed. For the same loose lift bed the loss in gravel content caused by the 8,559 kg static roller and the 825 kg vibratory roller, was observed to be in the range of 0% to 1% after the corresponding number of roller passes.

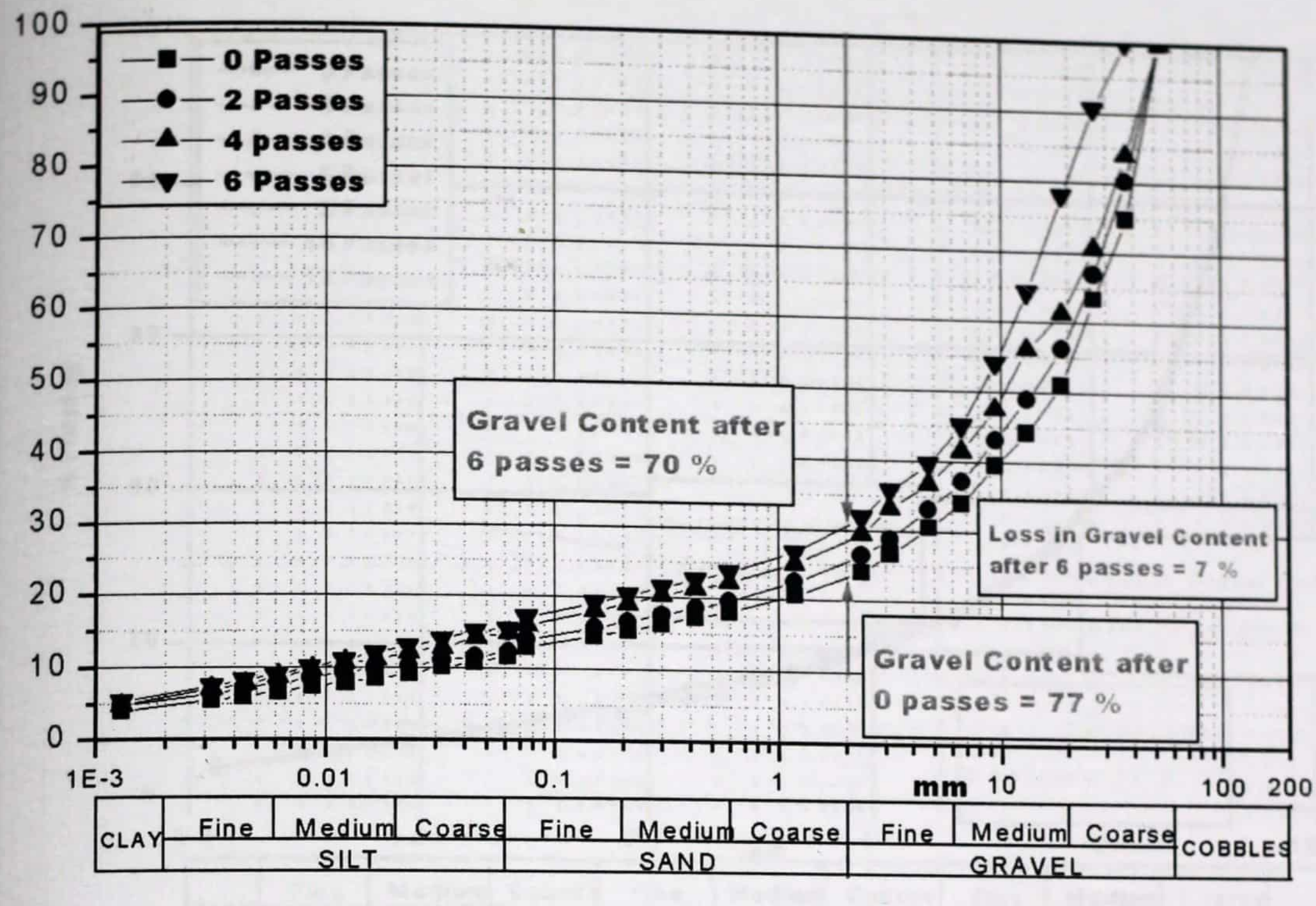

Figure 5.14 Particle Size Distribution after compacting with 15,380kg roller on 120mm loose bed

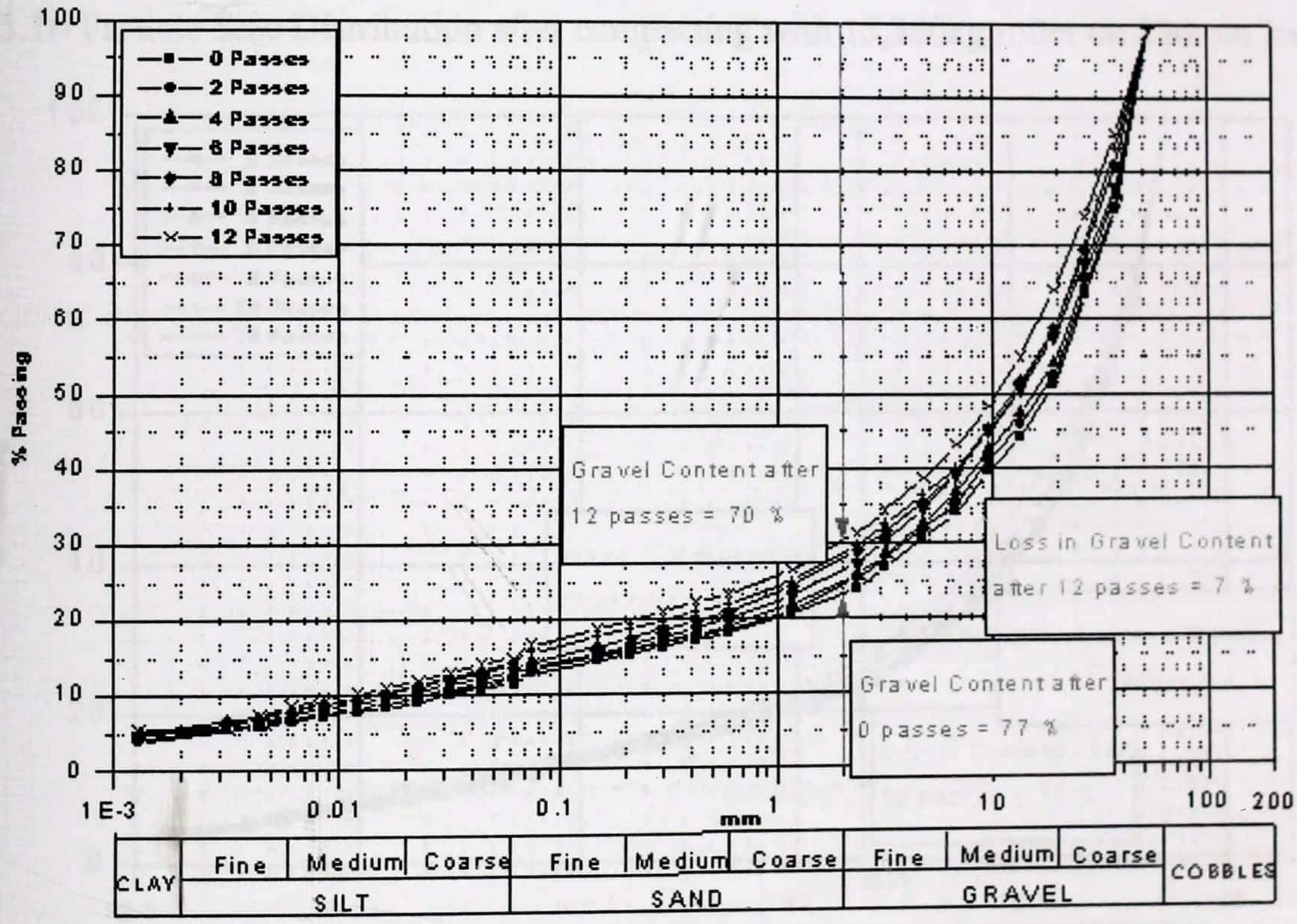

Figure 5.15 Particle Size Distribution after compacting with 15,380kg roller on 170mm loose bed

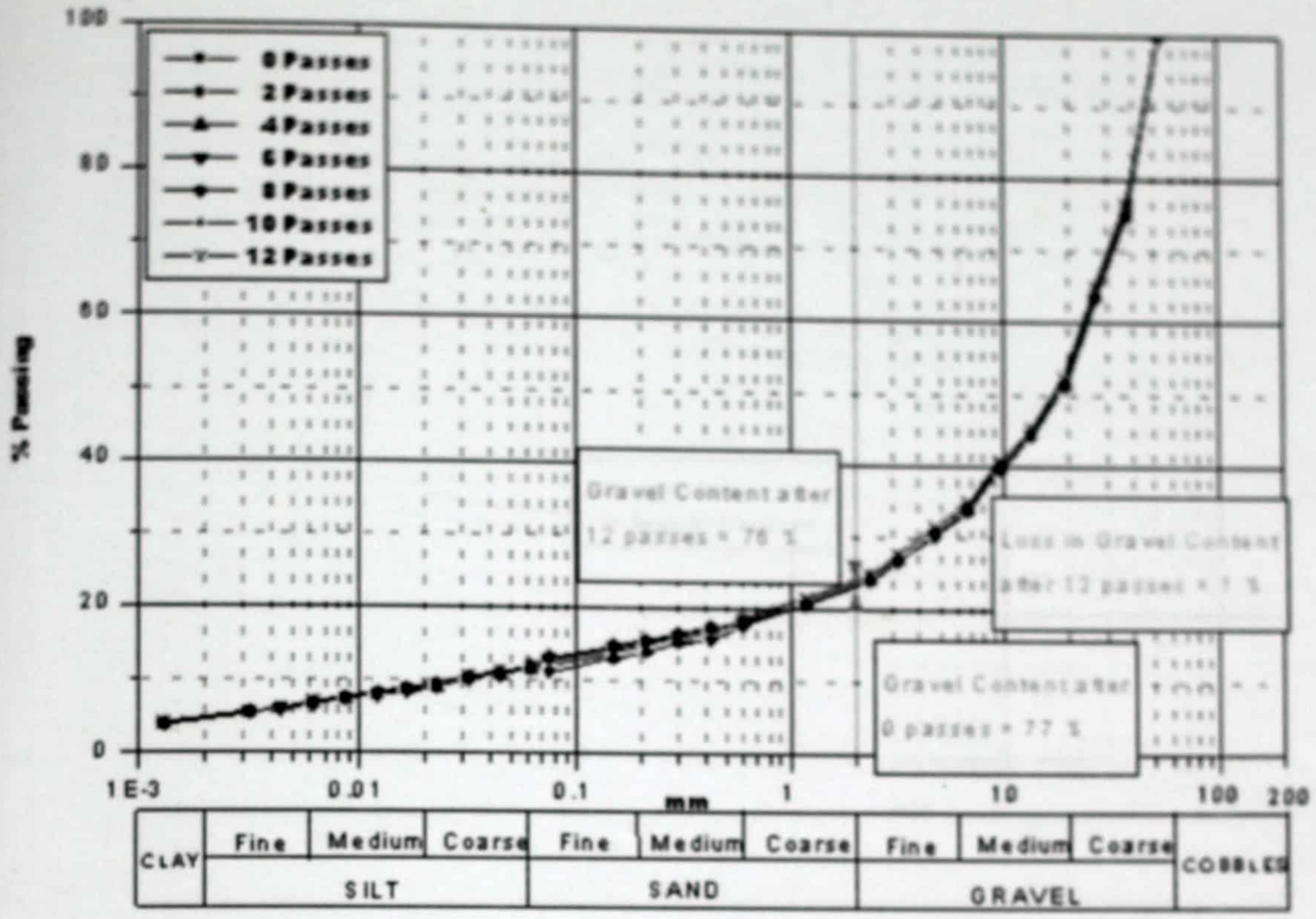

Figure 5.16 Particle Size Distribution after compacting with 15,380kg roller on 220mm loose bed

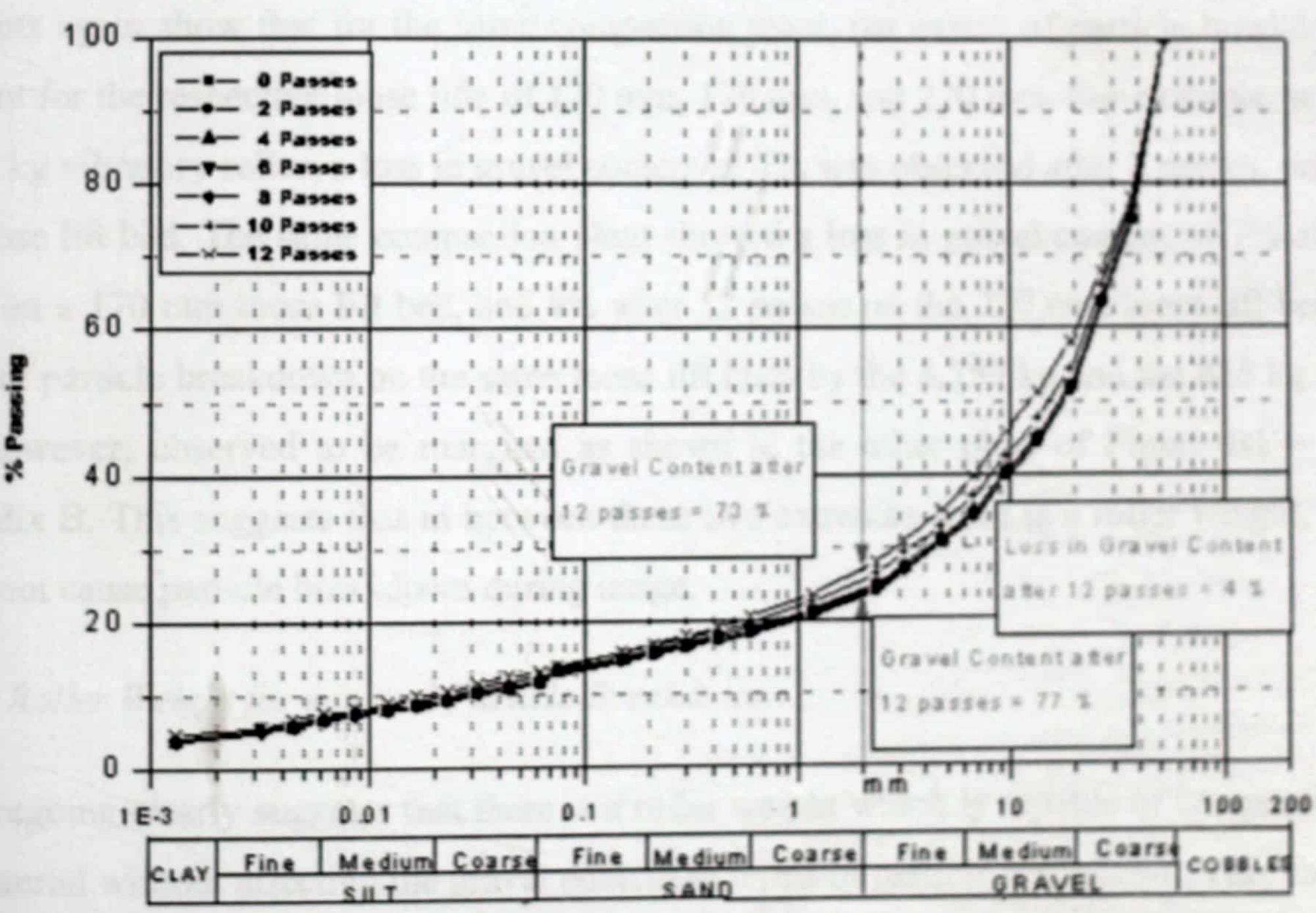

Figure 5.17 Particle Size Distribution after compacting with 8,559kg roller on 120mm loose bed

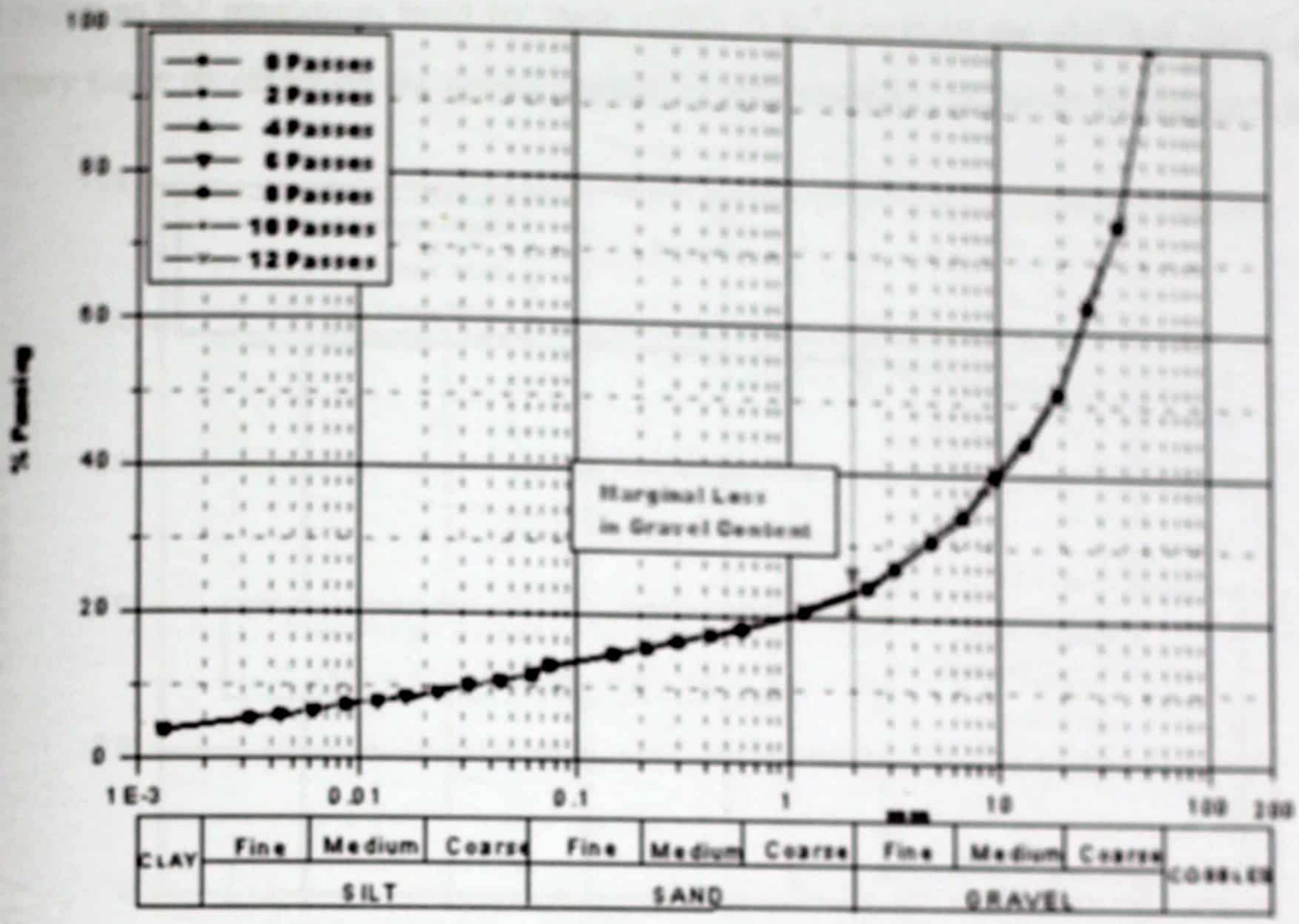

Figure 5.18 Particle Size Distribution after compacting with 825kg roller on 120mm loose bed

The plots again show that for the same compaction plant, the extent of particle breakdown is different for the respective loose lifts of 120 mm, 170 mm, and 220 mm. For example, with the 15,380 kg vibratory roller, a loss in gravel content of 7% was observed after 6 passes, on a 120 mm loose lift bed. The same compaction plant showed a loss in gravel content of 7% after 12 passes on a 170 mm loose lift bed, and 4% after 12 passes on the 220 mm loose lift bed. The extent of particle breakdown on the same loose lift beds by the 8,559 kg and the 825 kg rollers were however, observed to be marginal as shown in the other plots of Figure B1 – B4 in Appendix B. This suggests that in between these two extremes there is a roller weight, which would not cause particle breakdown during usage.

5.3.3 *Roller Weight for minimal Particle Breakdown*

The foregoing clearly suggests that there is a roller weight which is capable of compacting the soil material without affecting the gravel content in terms of particle breakdown. This has been illustrated in Figure 5.19. The plot was derived from the percentage of material passing the 2 mm test sieve after 6 passes for all the three loose lifts and compaction plants. The plot shows that a 9,000 kg roller would be a suitable compactor for the job on hand. It is interesting to note that the various road agencies under the Ministry of Roads and Transport do allow a 10,000 kg

weight roller as the maximum limit for their works. It is seen from the plot that this is equally satisfactory since its effect on the gravel content is only marginal as shown in Figure 5.19.

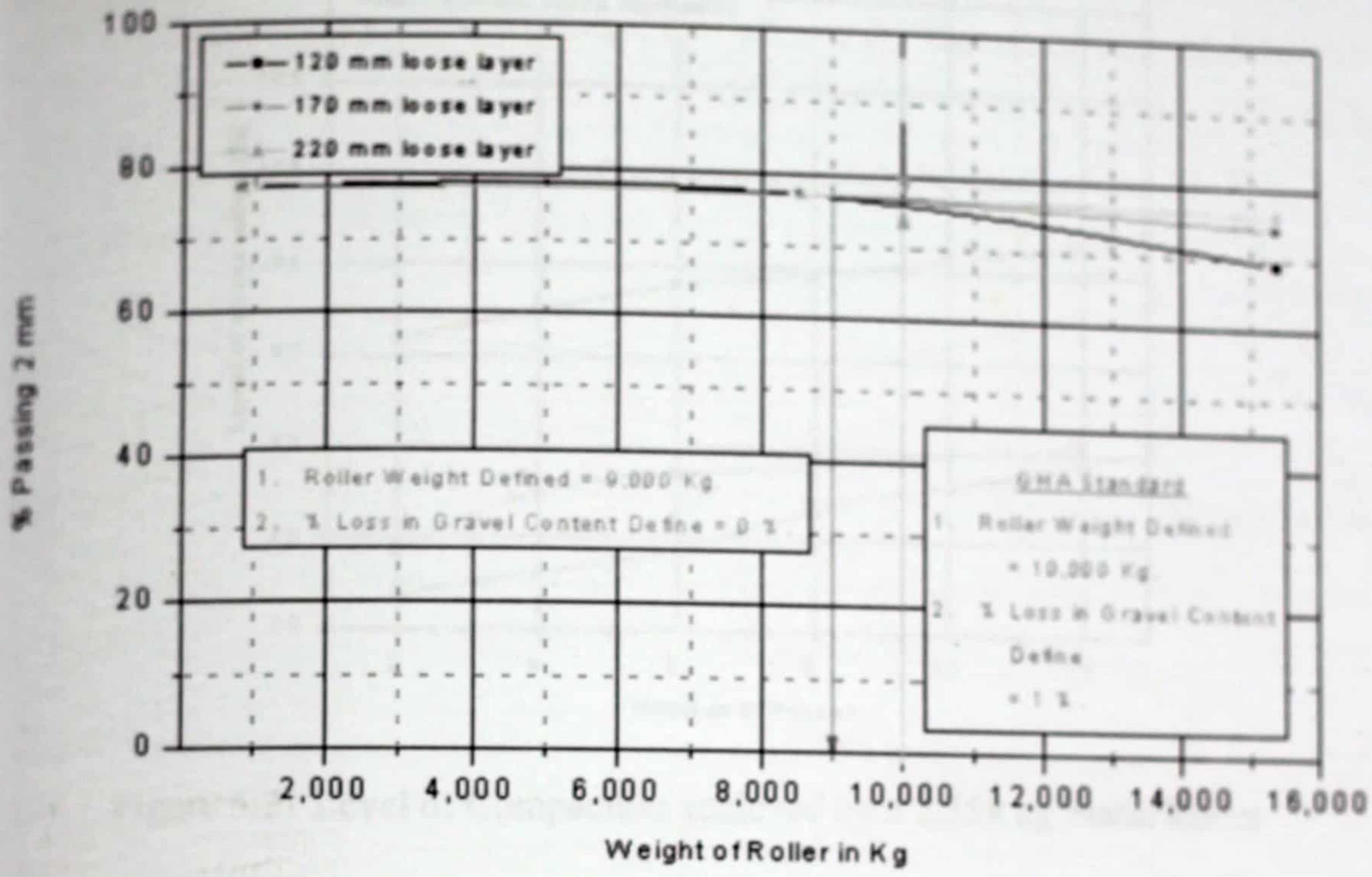

Figure 5.19 Effective Roller Weight

5.3.4 *Level of Compaction Achieved*

Figures 5.20-5.22 illustrate the level of compaction achieved by the 15,380 kg, 8,559 kg and 825 kg rollers on the loose layer thicknesses of 120 mm, 170 mm and 220 mm.

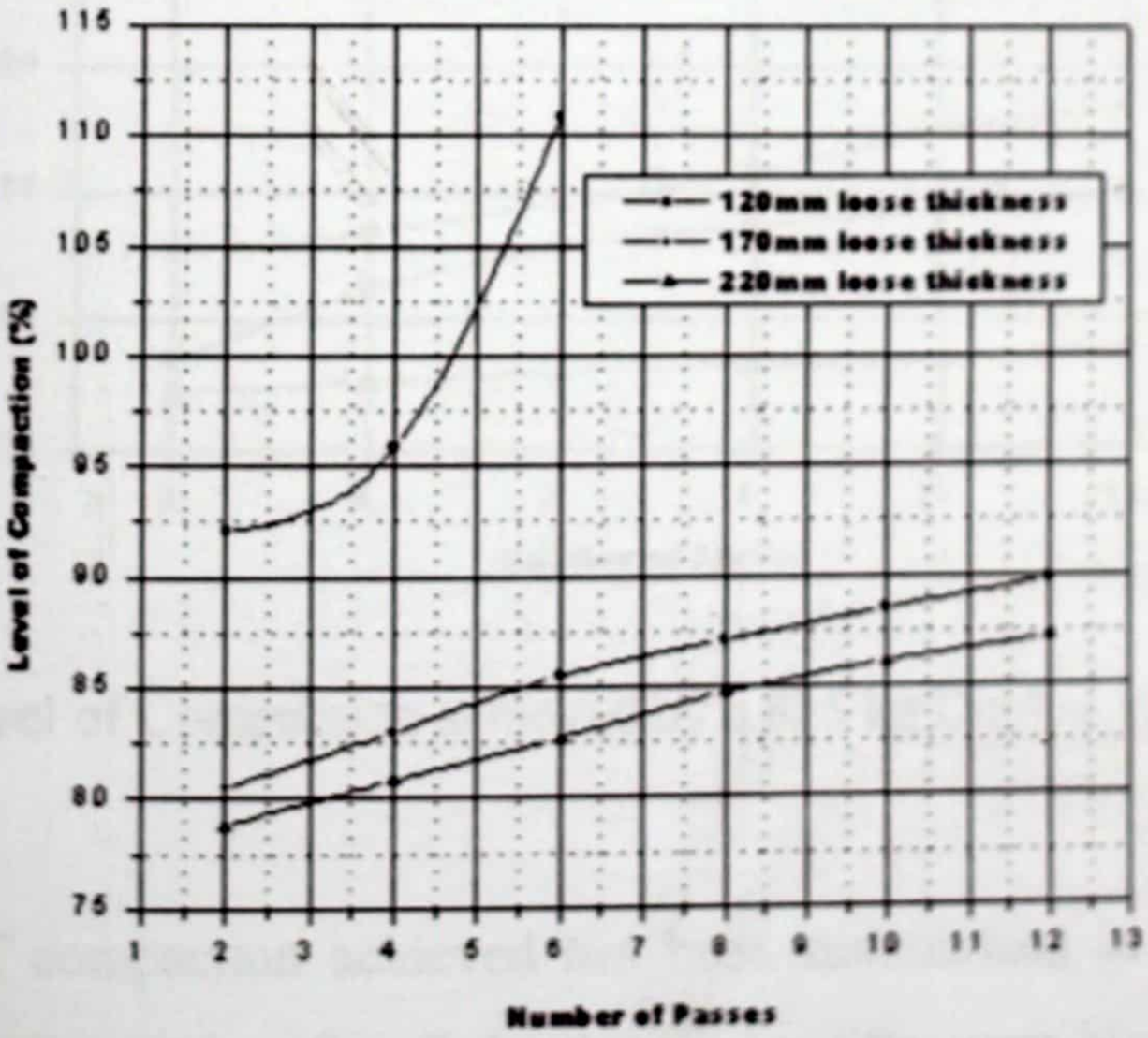

Figure 5.20 Level of Compaction achieved by a 15,380 kg Vibratory Roller

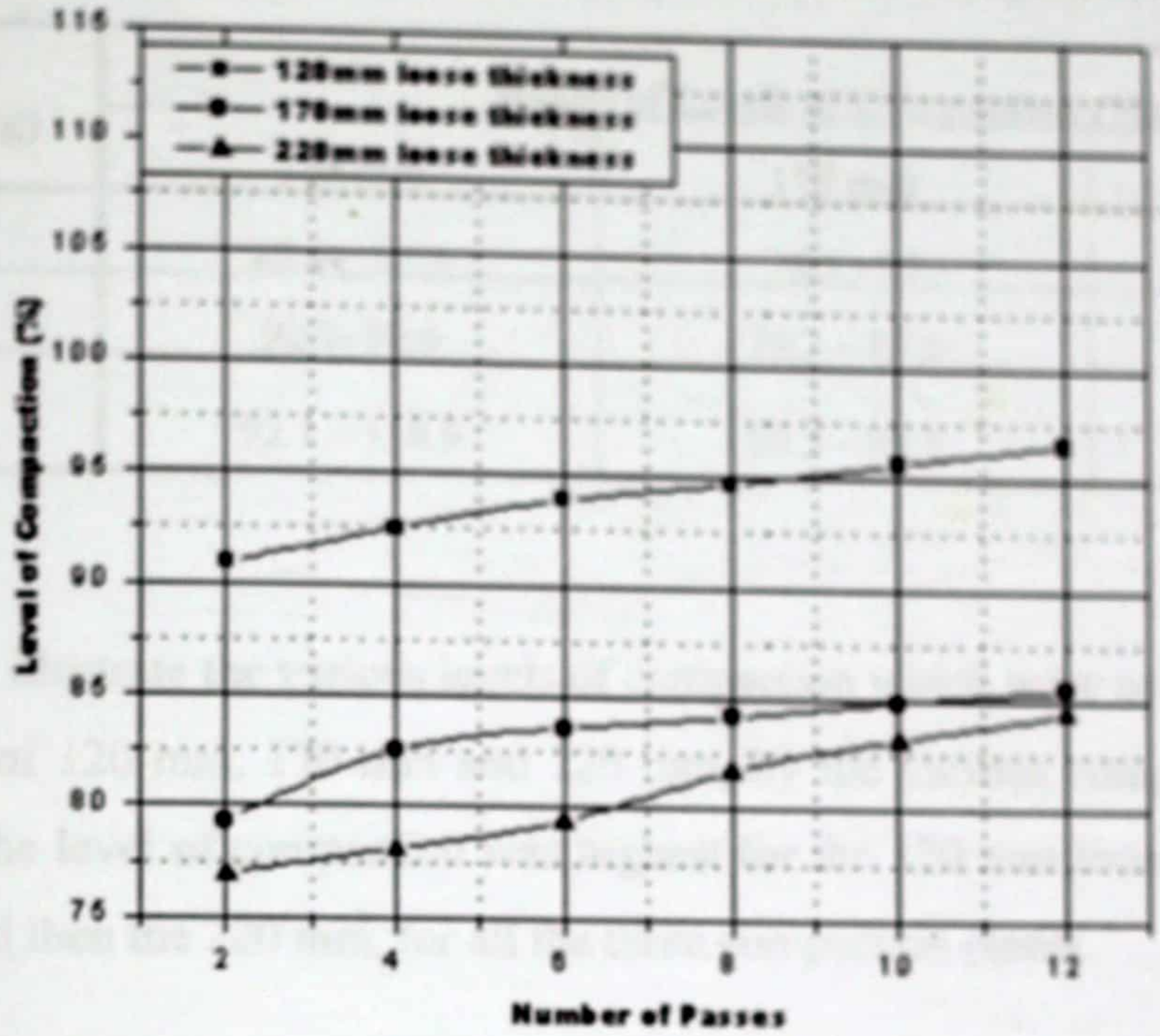

Figure 5.21 Level of Compaction achieved by a 8,559 kg Static Roller

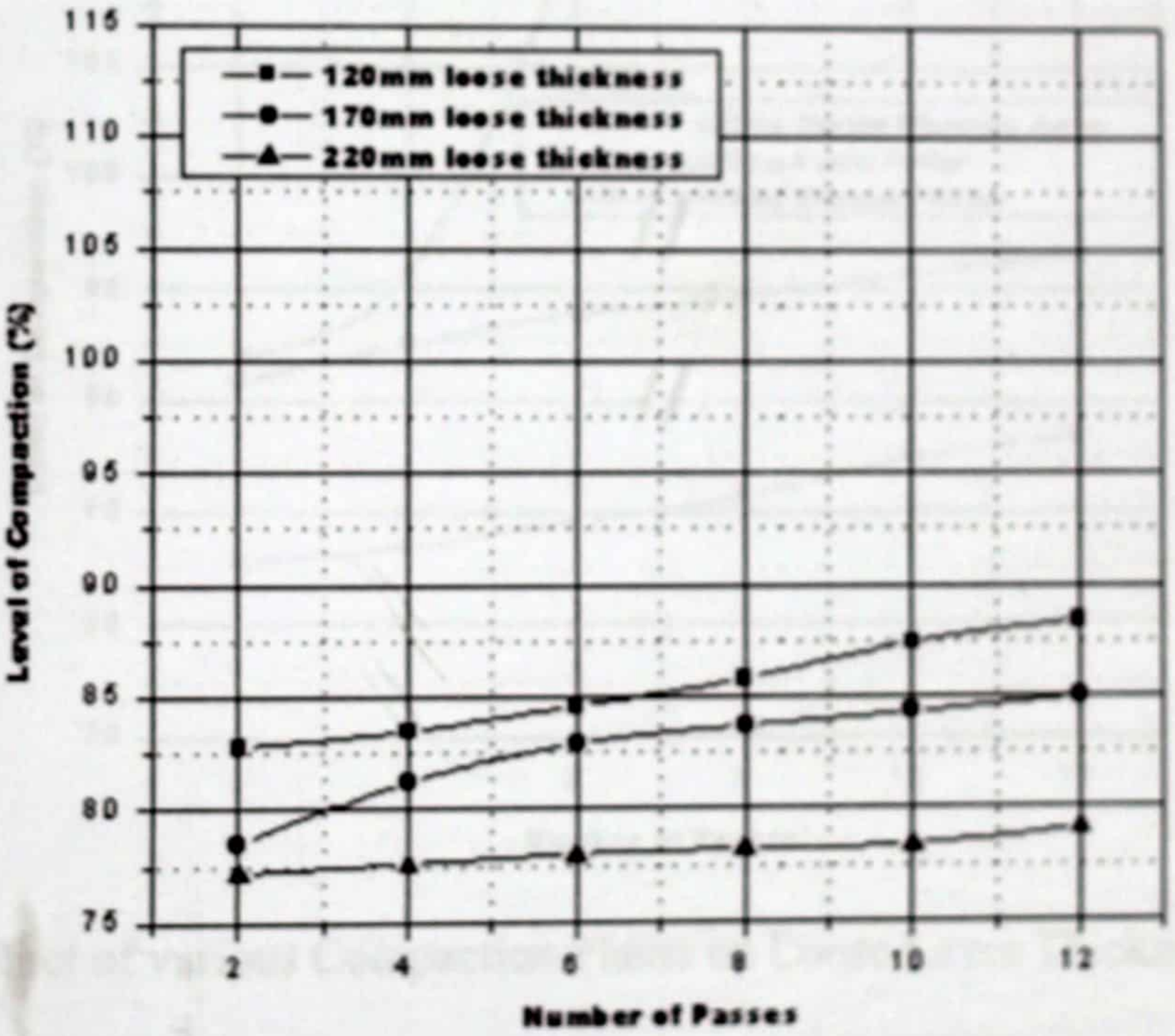

Figure 5.22 Level of Compaction achieved by a 825 kg Duplex Vibratory Roller

The range of level of compaction achieved has been summarised in Table 5.6 below. As expected the levels of compaction, for all the three loose lifts, were highest for the 15,380 kg roller, followed by the 8,559 kg and then the 825 kg rollers.

Table 5.6 Variations of Level of Compaction with Compaction Plants

Roller Weight (kg)	Range of Levels of Compaction (%)		
	120 mm	170 mm	220 mm
825 kg	82.8 – 88.4	78.5 - 85	77.2 – 79.1
8,559 kg	90.9- 96.6	79.3 – 85.5	77.9 – 84.4
15,380 kg	92.1 – 110.9	80.5 – 89.8	78.8 – 87.2

Figures 5.23-5.25, illustrate the various levels of compaction which were achieved on the loose layer thicknesses of 120 mm, 170 mm and 220 mm, by the various compaction plants. The figure show that the level of compaction was highest for the 120 mm loose lift bed, followed by the 170 mm and then the 220 mm, for all the three compaction plants.

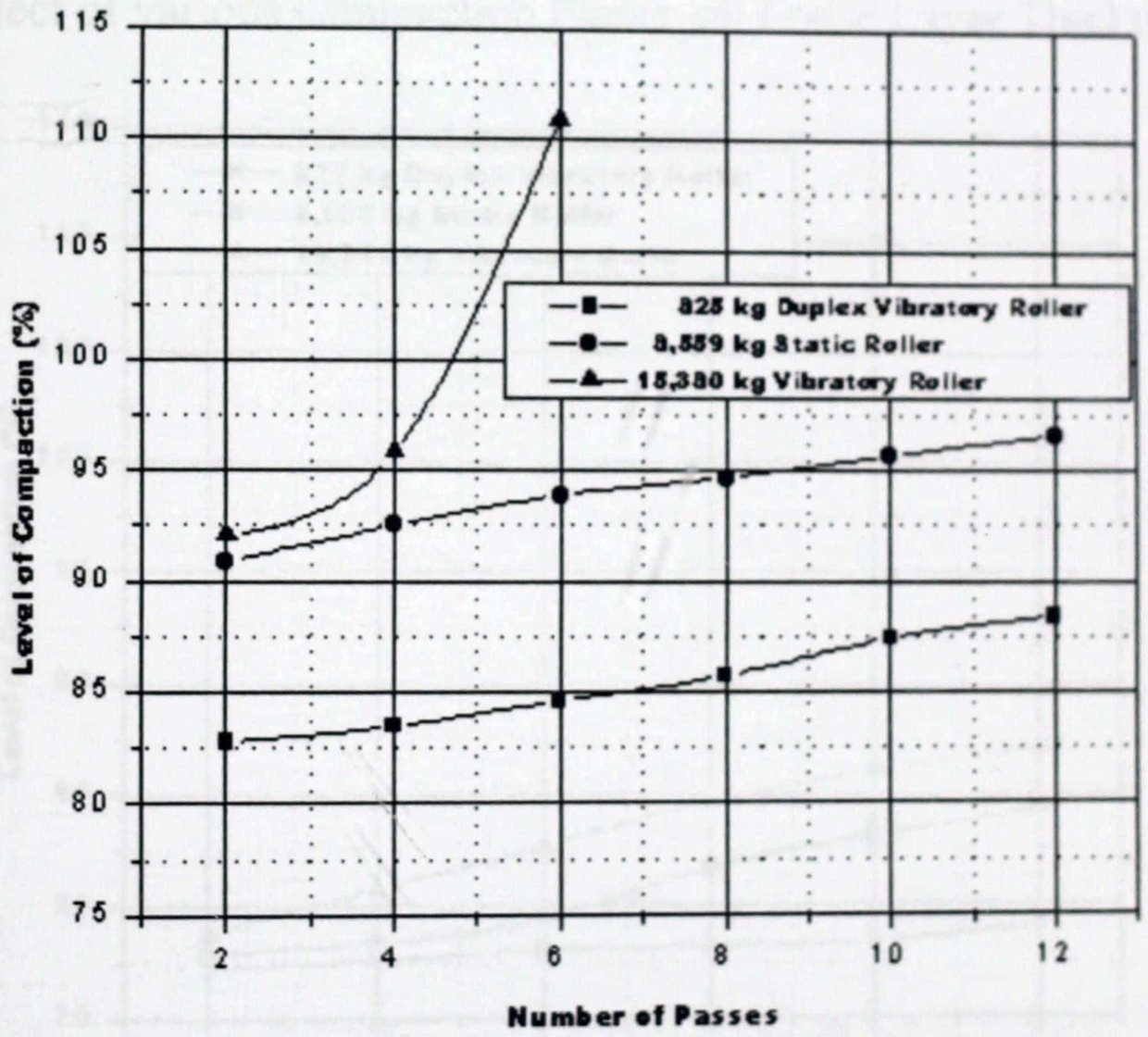

Figure 5.23 Effect of various Compaction Plants on Loose Layer Thickness of 120 mm

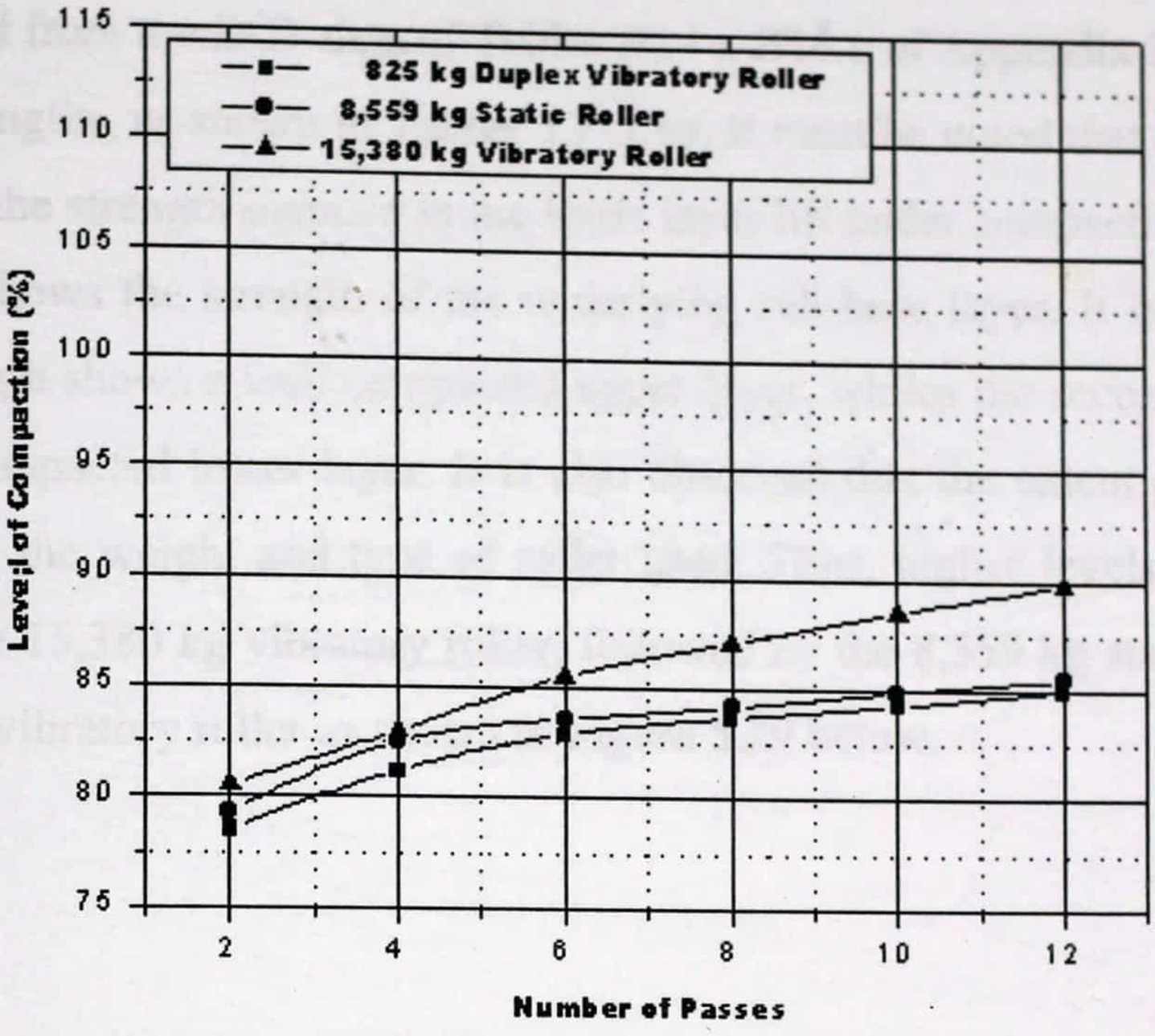

Figure 5.24 Effect of various Compaction Plants on Loose Layer Thickness of 120 mm

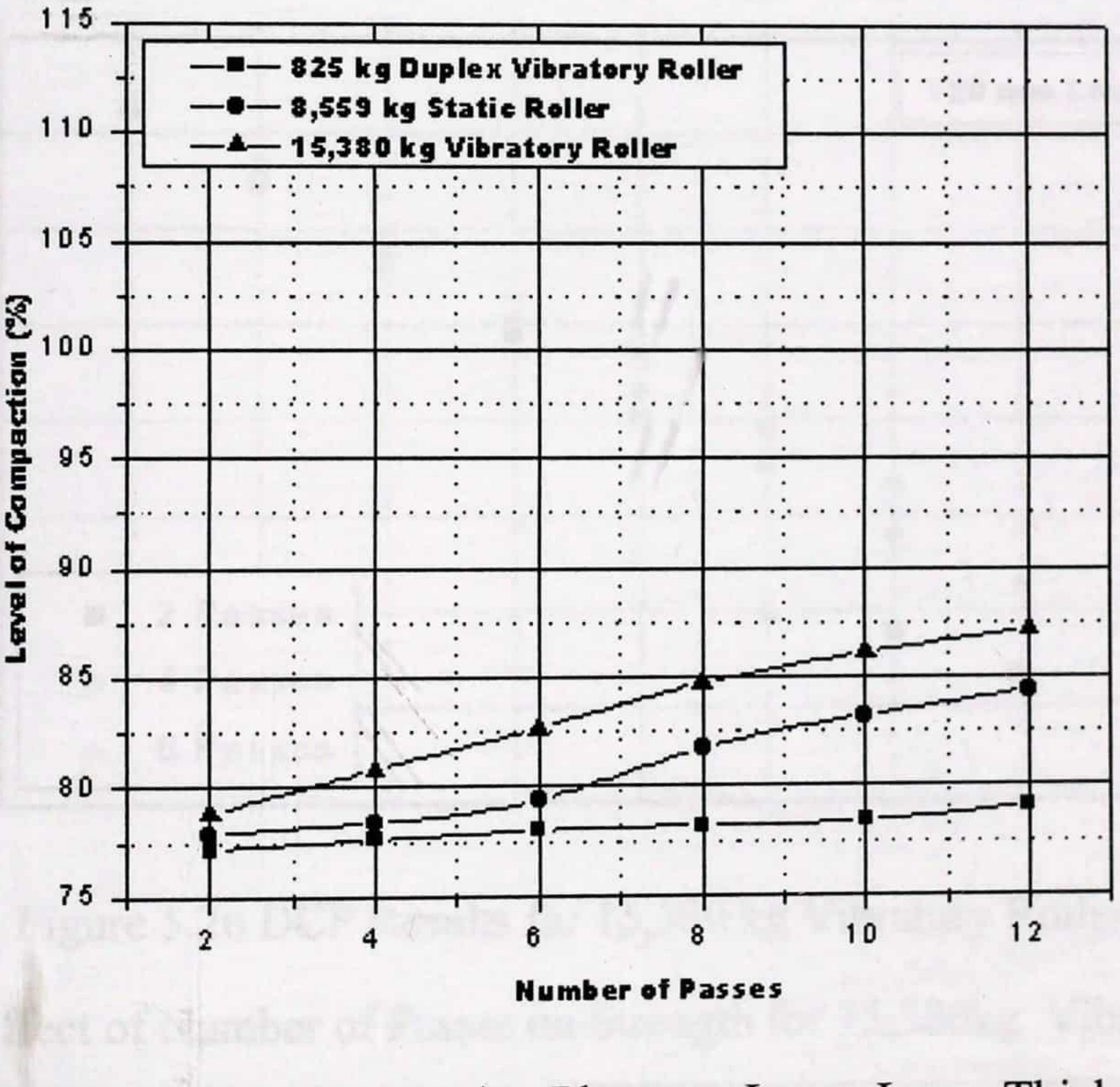

Figure 5.25 Effect of various Compaction Plants on Loose Layer Thickness of 170 mm

5.3.5 *Strength of the compacted soil*

Figures 5.26-5.30 show the various levels of strengths achieved for the various loose layer thicknesses, roller weights and number of passes made, on the soil material studied. The plots

have been obtained from the DCP data of Tables B14 a-B16 c of Appendix B. The plots depict three levels of strengths, as shown in Tables 5.7-5.10. It must be noted that the first two levels of strength define the strength induced in the loose layer lift under compaction whiles the third level of strength shows the strength of the underlying sub-base layer. It is observed that the first level of strength shows a well compacted upper layer, whiles the second level of strength shows a poorly compacted lower layer. It is also observed that the extent of gain in strength was influenced by the weight and type of roller used. Thus, higher levels of strengths were associated with the 15,380 kg vibratory roller, followed by the 8,559 kg static roller, and then the 825 kg duplex vibratory roller as shown in Figure 5.29 below.

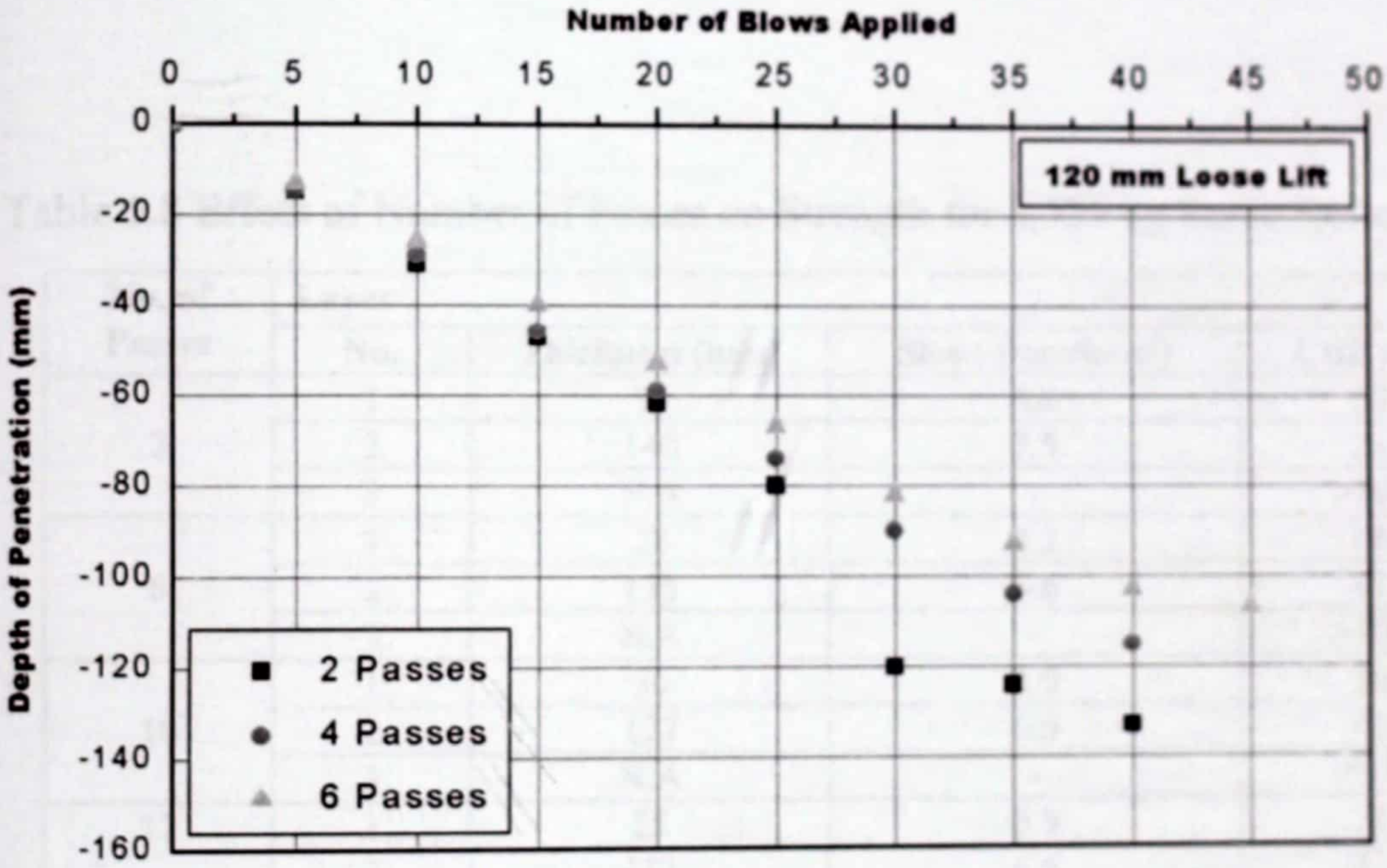

Figure 5.26 DCP Results for 15,380 kg Vibratory Roller

Table 5.7 Effect of Number of Passes on Strength for 15,380kg Vibratory Roller

No. of Passes	Laye			
	No.	Thickness (mm)	Slope (mm/blow)	CBR (%)
2	1	70	3.1	91
	2	45	4.5	62
	3	N.A	-	>100
4	1	101	3.0	95
	3	N.A	-	>100
6	1	100	2.6	110
	3	N.A	-	>100

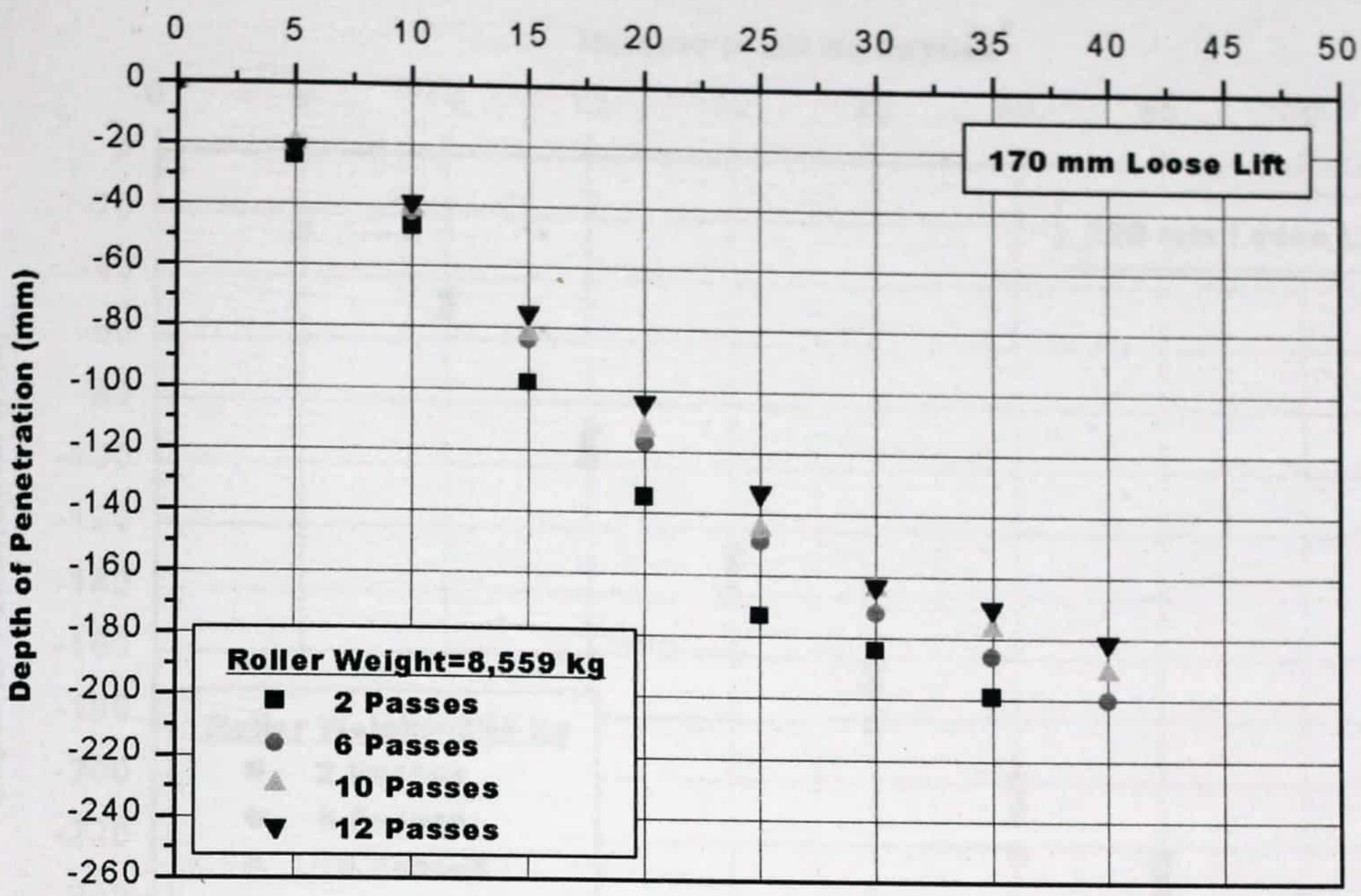

Figure 5.27 DCP Results for 8,559 kg Static Roller

Table 5.8 Effect of Number of Passes on Strength for 8,559 kg Static Roller

No. of Passes	Layer			
	No.	Thickness (mm)	Slope (mm/blow)	CBR (%)
2	1	30	4.6	60
	2	140	7.5	36
	3	N.A	-	>100
6	1	28	4.2	66
	2	135	6.6	41
	3	N.A	-	>100
10	1	30	4.0	70
	2	127	6.6	41
	3	N.A	-	>100
12	1	25	3.9	71
	2	133	6.6	41
	3	N.A	-	>100

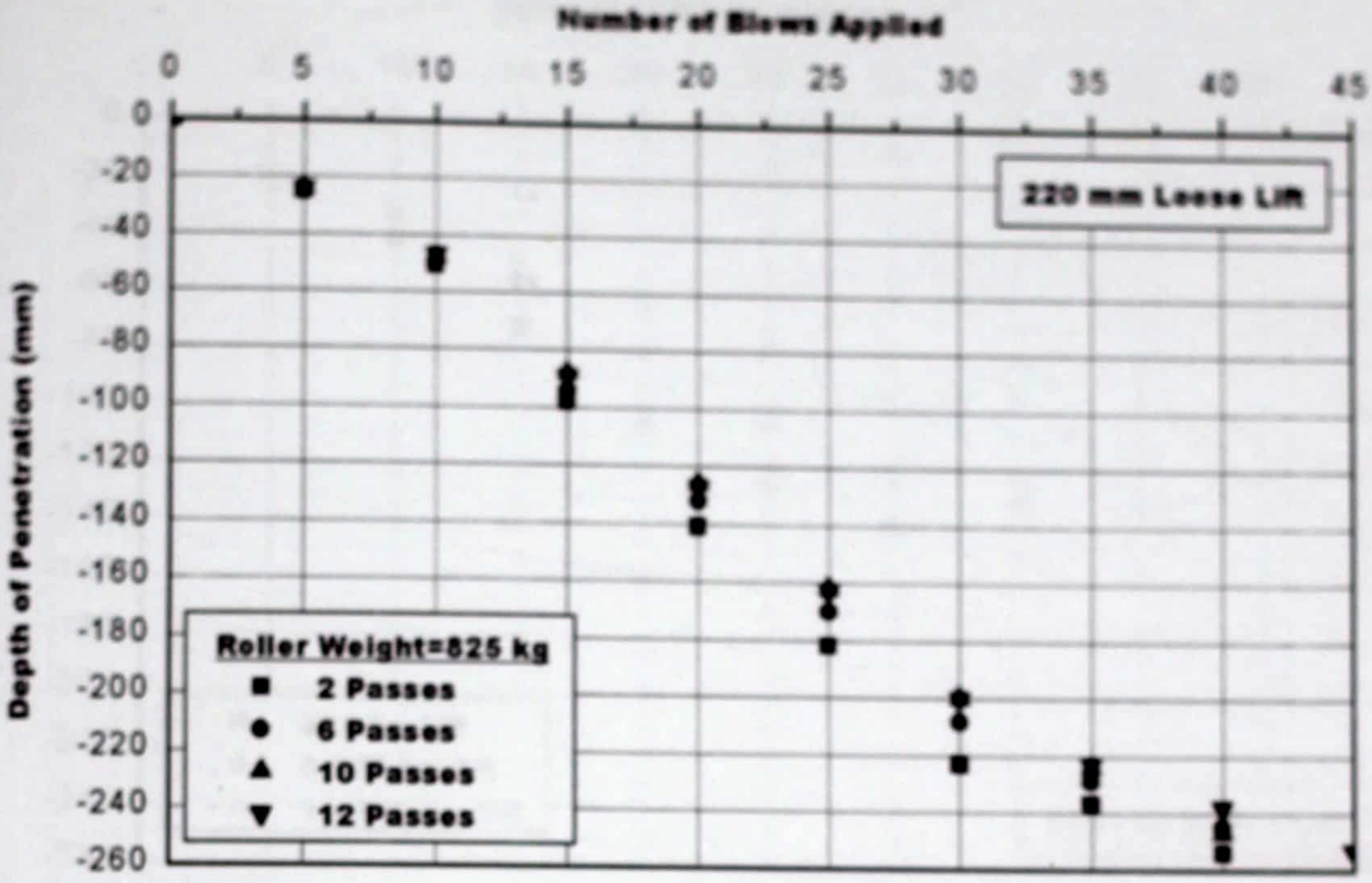

Figure 5.28 DCP Results for 825 kg Duplex Vibratory Roller

Table 5.9 Effect of Number of Passes on Strength for 825 kg Vibratory Roller

No. of Passes	Layer			
	No.	Thickness (mm)	Slope (mm/blow)	CBR (%)
2	1	41	5.1	54
	2	179	8.1	33
	3	N.A	-	>100
6	1	40	4.9	56
	2	178	7.7	35
	3	N.A	-	>100
10	1	48	4.8	58
	2	169	7.7	35
	3	N.A	-	>100
12	1	40	4.7	59
	2	172	7.7	35
	3	N.A	-	>100

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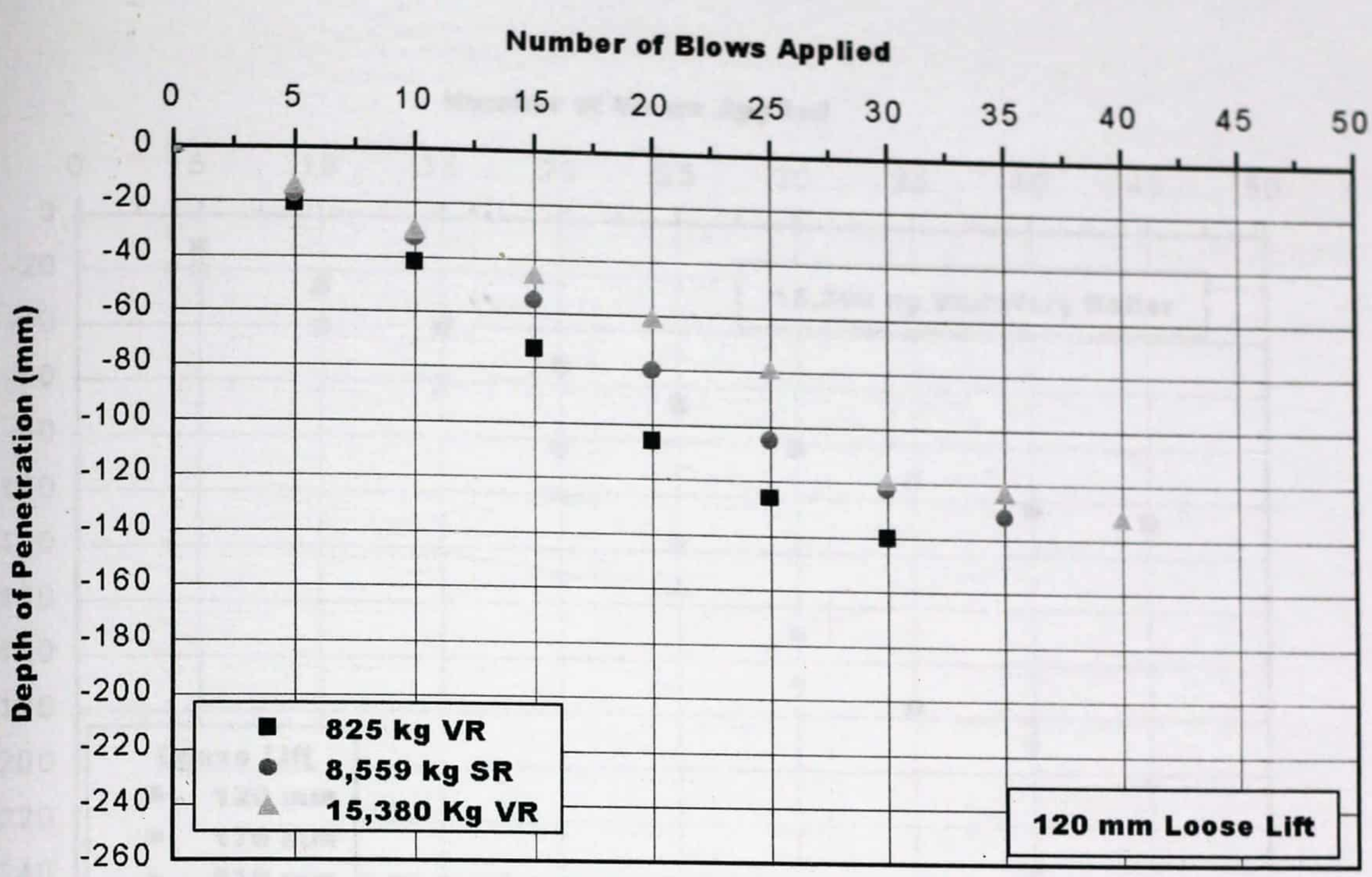

Figure 5.29 DCP Results for various Compaction Plants after 6 passes

Table 5.10 Effect of Compaction Plants on 120 mm loose lift bed

Roller Weight (kg)	No. of Passes	Layer			
		No.	Thickness (mm)	Slope (mm / blow)	CBR (%)
15,380	6	1	100	2.6	110
		3	N.A	-	>100
8,559	6	1	40	3.1	91
		2	178	5	55
		3	N.A	-	>100
825	6	1	48	4.2	68
		2	169	6.2	44
		3	N.A	-	>100

Figure 5.30 also shows that for the same compaction plant, the extent of gain in strength varies for different thickness of loose lifts. The thicker the loose bed the lower the gain in strength on compaction.

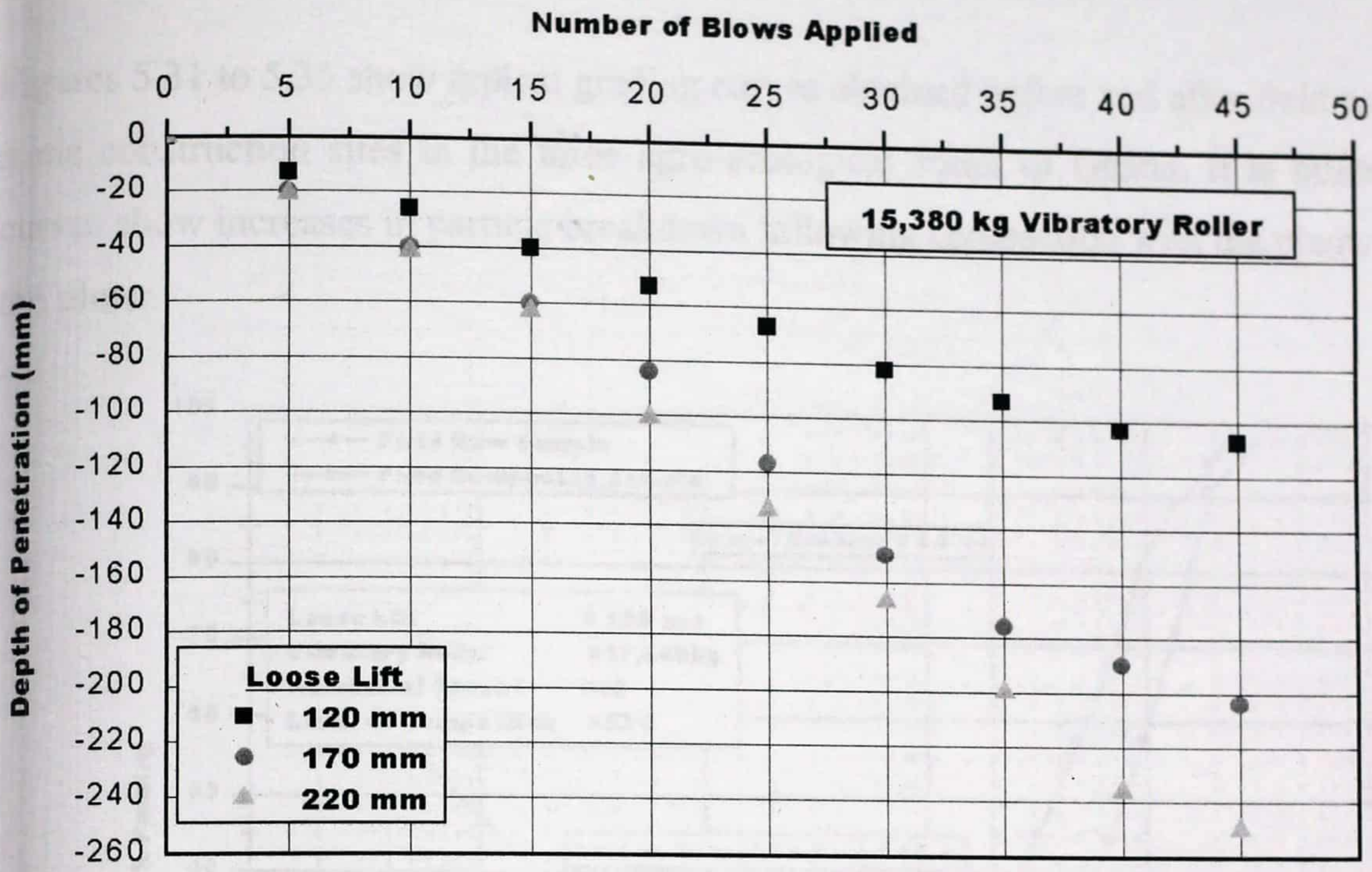

Figure 5.30 Effect of Loose Lift on Strength at 6 Passes

Table 5.11 Effect of Loose Lift on Strength using 15,380 kg Vibratory Roller

Loose Lift (mm)	No. of Passes	Layer			
		No.	Thickness (mm)	Slope (mm / blow)	CBR (%)
120	6	1	100	2.6	110
		3	N.A	-	>100
170	6	1	78	4.0	70
		2	90	6.6	41
		3	N.A	-	>100
220	6	1	59	4.2	66
		2	157	6.6	41
		3	N.A	-	>100

5.4 Construction Site Compaction Studies

The test results obtained for the construction site compaction studies have been discussed in detail under the following headings:

- Effect of Compactive Effort on Particle Size Distribution.
- Effect of Compactive Effort on Plasticity of the Fines.

5.4.1 *Effect of Compactive Effort on Particle Size Distribution*

Figures 5.31 to 5.35 show typical grading curves obtained before and after field compaction on some construction sites in the three agro-ecological zones of Ghana. It is observed that the curves show increases in particle breakdown following compaction with the plants indicated on the plots.

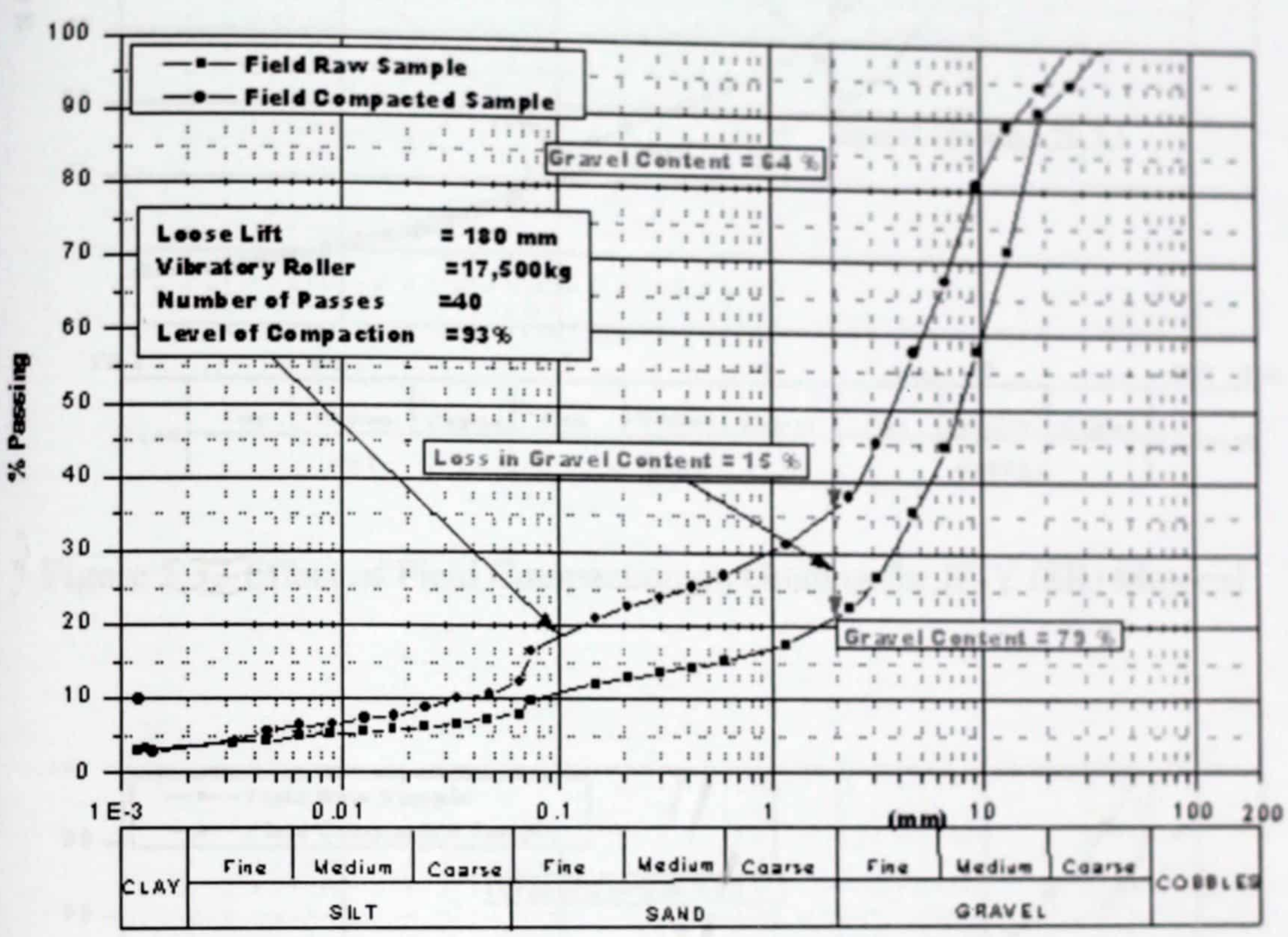

Figure 5.31Effect of Field Compaction on Grading for T-K (SB) Material

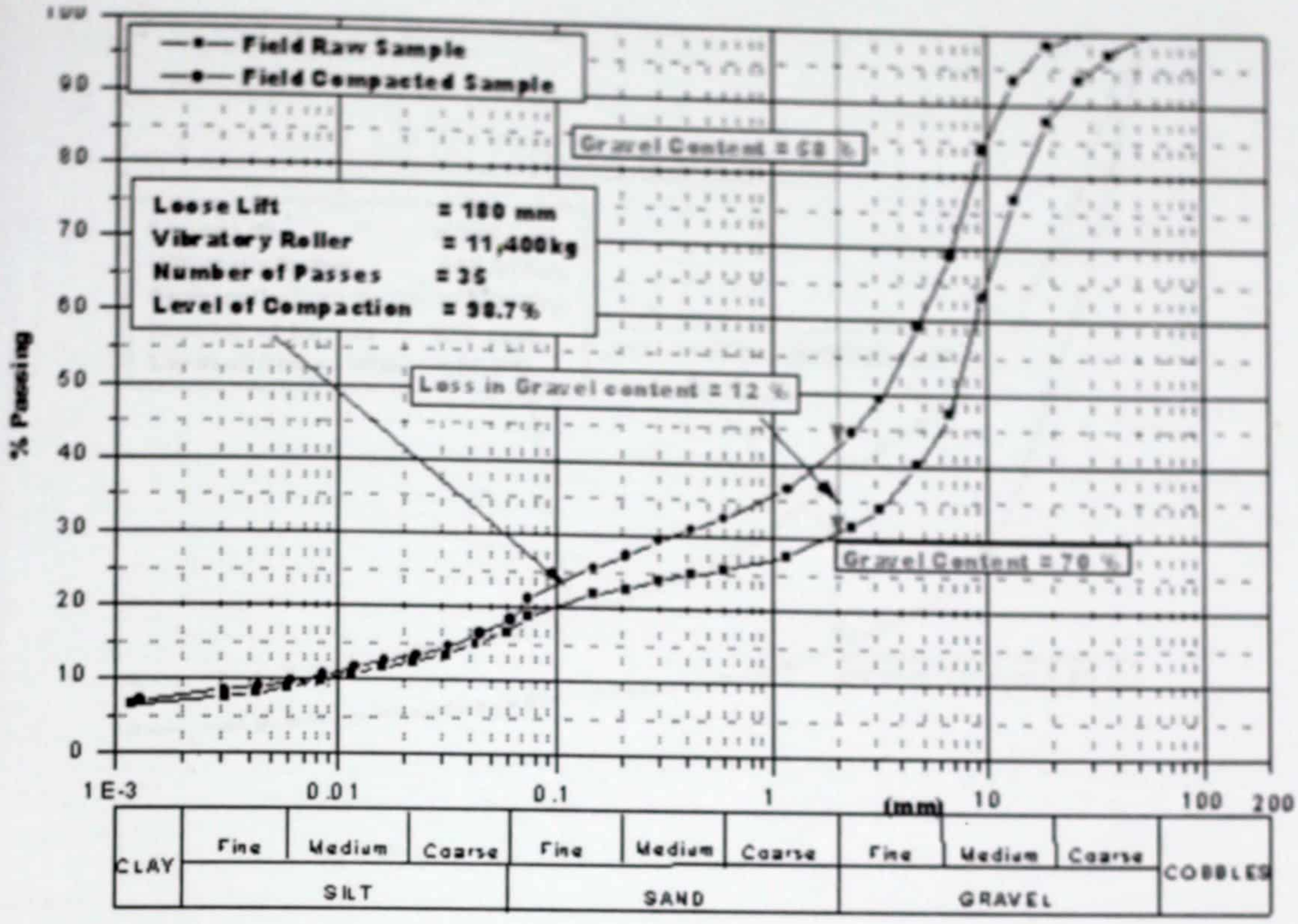

Figure 5.32 Effect of Field Compaction on Grading for JZ-Y (SB) Material

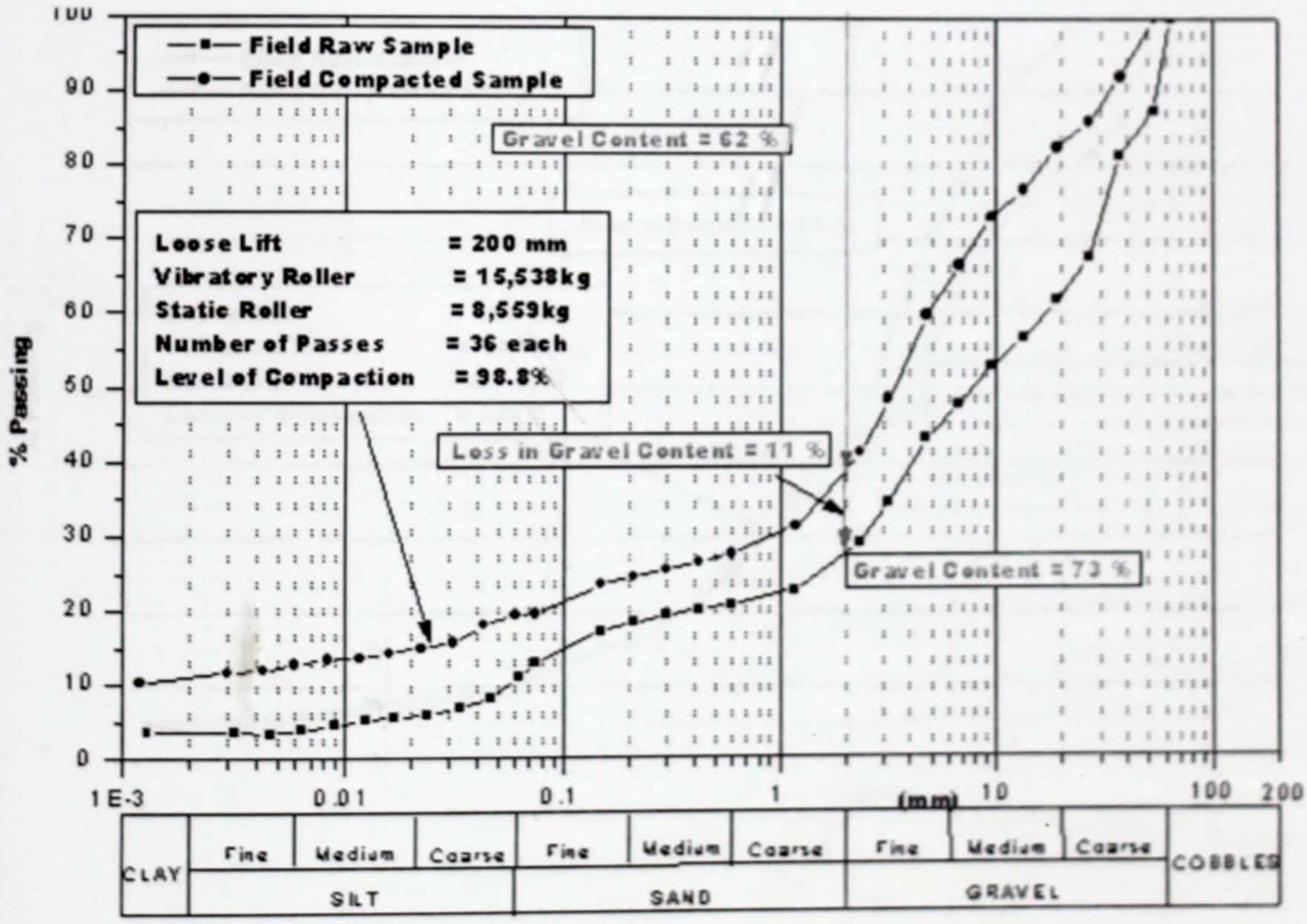

Figure 5.33 Effect of Field Compaction on Grading for GR (B) Material

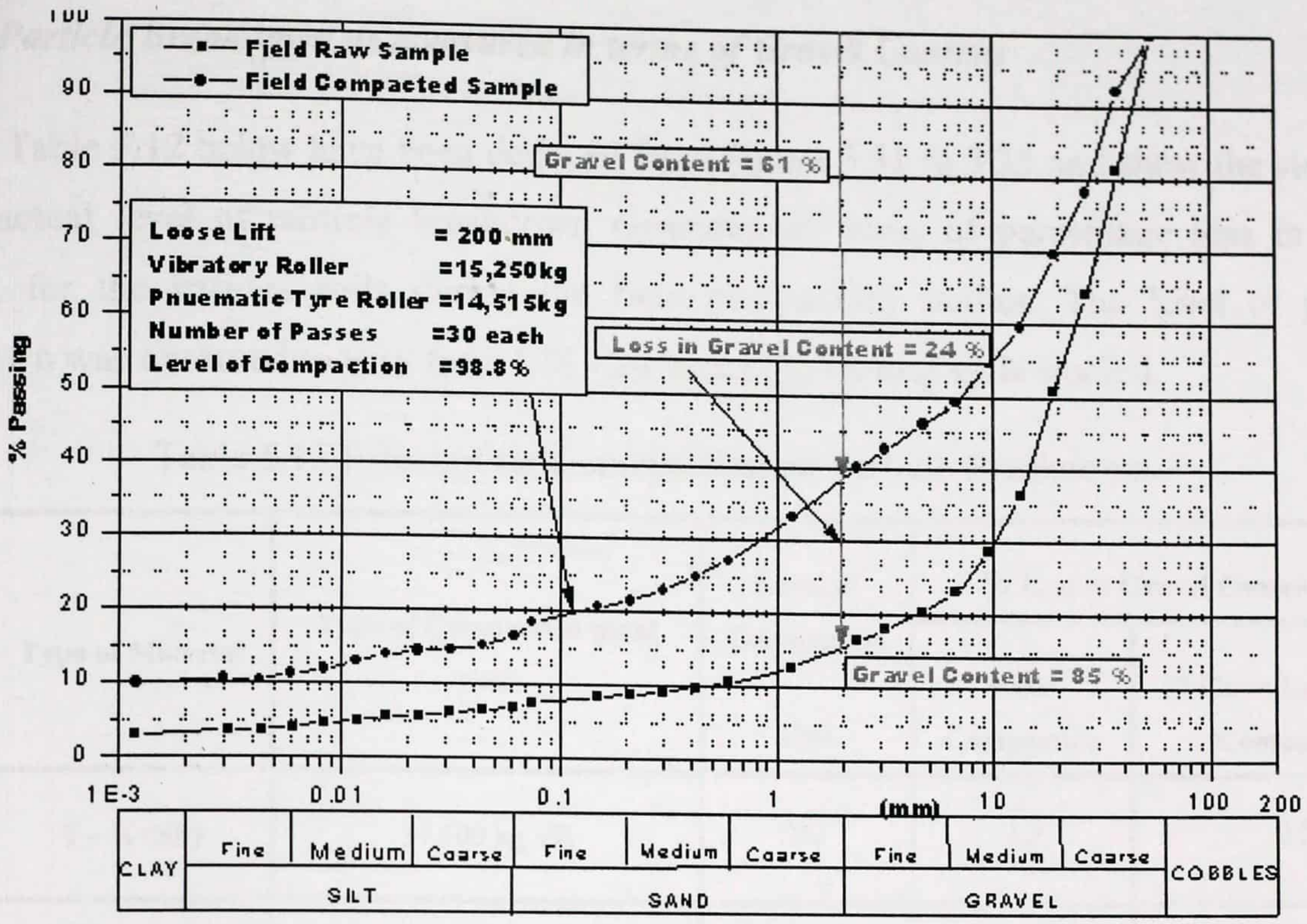

Figure 5.34 Effect of Field Compaction on Grading for A-N (SB) Material

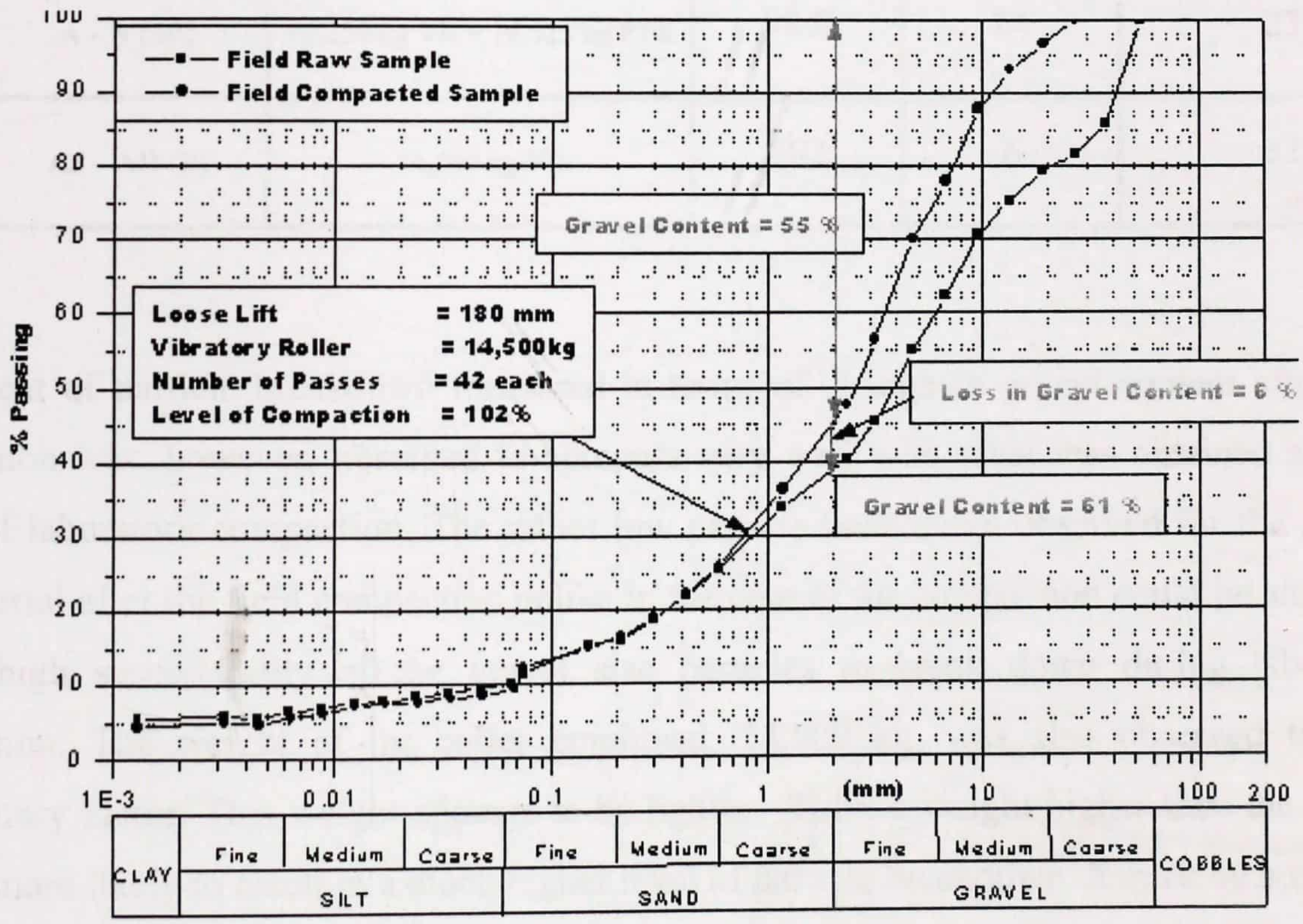

Figure 5.35 Effect of Field Compaction on Grading for AJ-AD (B) Material

5.4.2 *Particle Breakdown as measured in terms of Gravel Content*

Data in Table 5.12 below have been deduced from Figure 5.31 to 5.35 and show the summary of the actual level of particle breakdown measured in terms of percentage loss in gravel content, for the various soils during the field compaction studies. The level of particle breakdown was observed to vary from 6 % - 24 % for the various soils studied.

Table 5.12 Effect of field compaction on Particle Breakdown

Zone	Type of Material	Type of Compaction plant used	Level of Compaction (%)	% Loss in Gravel Content after	
				Field Compaction	55 blows Laboratory Compaction
1	**T – K (SB)**	17,500 kg VR	93	15	15
2	**JZ – Y (SB)**	11,400 kg VR	98.7	12	10
	GR (B)	15,538 kg VR + 8,559 kg SR	98.8	11	13
	A - N (SB)	15,250 kg VR + 14,515 kg PTR	98.8	24	23
3	**AJ – AD (B)**	14,500 kg VR	102	6	33

The extent of particle breakdown measured in terms of change in gravel content after field compaction was, however, observed to compare very well with what was obtained after 55 blows of laboratory compaction. The rather low particle breakdown observed for the AJ-AD (B) material after the field compaction unlike in the case of the compaction could be attributed to the high susceptibility of the gravel size particles to break down during laboratory compaction. The weight of the roller employed, 14,500 kg, was also observed to be a contributory factor. This weight appears to be lighter. Thus, a weight higher than the 14,500 kg was more likely to result in a much higher level of particle breakdown. It must be noted that the 15 % loss in gravel content recorded for T-K (SB) resulted from a level of compaction of only 93 %. Thus, a 98 % level of compaction was likely to cause a higher level of change in gravel content.

6. CONCLUSIONS AND RECOMMENDATION

6.1 CONCLUSIONS

Based upon the results of the laboratory compaction, model site compaction studies and field compaction the following conclusions can be derived:

(1) Particle breakdown occurred for soil samples from all the three Agro Ecological Zones of Ghana during laboratory compaction using the Modified AASHTO standard.

(a) The extent of breakage, however, was different for different soils and varied from a minimum of 1% to a maximum of 19% decrease in gravel content.

(b) In the laboratory compaction, particle breakdown was observed to occur only during the initial stages of compaction.

(c) The breakdown of particles did not significantly affect the Aatterberg Limits.

(2) Increases in specific energy during laboratory compaction lead to the progressive increase in the level of compaction. The rate of increase in level of compaction was observed to be approximately proportional to the logarithm of the specific energy.

(a) Higher levels of compaction did not always lead to higher CBR values, for both soaked and unsoaked samples. Though unsoaked CBR values were observed to be generally higher than the corresponding soaked CBR values, instances of soaked CBR values being higher than the unsoaked CBR values were observed

(3) During model site studies, particle breakdown occurred for the same soil material and loose layer lift, during compaction with different compaction plants ranging from 825 kg duplex vibratory roller to the 15,380 kg vibratory roller.

(a) For the same soil material and the same compaction plant, the level of particle breakage ~~experi~~enced during compaction were different for the different loose lifts of 120mm, 170 mm, and 220 mm.

(b) Heavy compaction plants cause more particle breakdown than lighter compaction plants.

(c) The generation of fines during compaction generally improves grading and voids condition of a soil material and thus enable it to achieve higher strength.

(d) A 9,000 kg roller was observed to be an ideal compaction plant for soils in the field as it caused minimal particle breakdown.

(e) During field compaction, soil materials experience a progressive gain in strength which builds up from the upper surface of the layer into the depth of the lift. For the same soil material and compaction plant, the level of strength achieved for the same number of passes was higher for the 120 mm than the 220 mm.

(4) Field compaction causes particle breakdown. The extent of breakdown measured by the decrease in gravel content varied from a low of 6 % to a high of 24 % depending on the type of soil, the type of compaction plant used and the number of roller passes made.

6.2 RECOMMENDATION

It is highly recommended that:

1. Further studies is made in order to obtain the range of soil materials that have the tendency to lose strength at higher compactive efforts or level of compaction.

2. Further studies in the determination of in-situ CBR is carried out in the field in order to assess the extent of strength loss during actual field compaction due to particle breakdown.

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APPENDIX A

Table A1 a GRADING FOR T-K (B) AFTER 55 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	12.7	1.3	98.7
$^3/_8$ in	9.50	23.2	2.3	96.4
$^1/_4$ in	6.70	69.9	7.0	89.4
$^3/_{16}$ in	4.75	99.6	10.0	79.5
$^1/_8$ in	3.18	168.7	16.9	62.6
No. 7	2.36	97.0	9.7	52.9
No. 14	1.18	13.3	14.0	38.9
No. 25	0.600	7.0	7.4	31.5
No. 36	0.425	1.8	1.9	29.6
No. 52	0.300	1.7	1.8	27.8
No. 72	0.212	1.7	1.8	26.1
No. 100	0.150	2.4	2.5	23.5
No. 200	0.075	3.2	3.4	20.1
Passing No. 200				
Total		374.0		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight 50g Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	24.0	0.5	1.0130	13.0	13.5	147.28	0.909	0.0667	0.8069	10.21	16.97
	24.0	1.0	1.0110	11.0	11.5	155.18	0.909	0.0484	0.8069	8.21	13.64
	24.0	2.0	1.0106	10.6	11.1	156.76	0.909	0.0344	0.8069	7.81	12.98
	24.0	4.0	1.0090	9.0	9.5	163.08	0.91	0.0248	0.8069	6.21	10.32
	24.0	8.0	1.0085	8.5	9.0	165.05	0.91	0.0177	0.8069	5.71	9.49
	24.0	15.0	1.0081	8.1	8.6	166.63	0.91	0.0130	0.8069	5.31	8.82
	24.0	30.0	1.0075	7.5	8.0	169.00	0.91	0.0092	0.8069	4.71	7.83
	24.0	60.0	1.0071	7.1	7.6	170.58	0.91	0.0066	0.8069	4.31	7.16
	24.0	120	1.0066	6.6	7.1	172.56	0.91	0.0047	0.8069	3.81	6.33
	24.0	240	1.0058	5.8	6.3	175.72	0.91	0.0033	0.8069	3.01	5.00
	24.0	1440	1.0050	5.0	5.5	178.88	0.91	0.0014	0.8069	2.21	3.67

Table A1 b GRADING FOR T-K (B) AFTER 25 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	31.5	3.1	96.9
$^3/_8$ in	9.50	24.8	2.5	94.4
$^1/_4$ in	6.70	77.9	7.8	86.6
$^3/_{16}$ in	4.75	114.4	11.4	75.1
$^1/_8$ in	3.18	163.9	16.4	58.7
No. 7	2.36	94.1	9.4	49.3
No. 14	1.18	13.9	13.7	35.6
No. 25	0.600	7.1	7.0	28.6
No. 36	0.425	1.9	1.9	26.7
No. 52	0.300	1.8	1.7	25.0
No. 72	0.212	1.6	1.6	23.4
No. 100	0.150	2.3	2.3	21.1
No. 200	0.075	4.6	4.5	16.6
Passing No. 200				
Total		412.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight 50g Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	24.0	0.5	1.0132	13.2	13.7	146.49	0.909	0.0666	0.8069	10.41	16.12
	24.0	1.0	1.0115	11.5	12.0	153.20	0.909	0.0481	0.8069	8.71	13.49
	24.0	2.0	1.0104	10.4	10.9	157.55	0.909	0.0345	0.8069	7.61	11.79
	24.0	4.0	1.0094	9.4	9.9	161.50	0.91	0.0247	0.8069	6.61	10.24
	24.0	8.0	1.0085	8.5	9.0	165.05	0.91	0.0177	0.8069	5.71	8.84
	24.0	15.0	1.0081	8.1	8.6	166.63	0.91	0.0130	0.8069	5.31	8.22
	24.0	30.0	1.0072	7.2	7.7	170.19	0.91	0.0093	0.8069	4.41	6.83
	24.0	60.0	1.0065	6.5	7.0	172.95	0.91	0.0066	0.8069	3.71	5.74
	24.0	120	1.0056	5.6	6.1	176.51	0.91	0.0047	0.8069	2.81	4.35
	24.0	240	1.0052	5.2	5.7	178.09	0.91	0.0033	0.8069	2.41	3.73
	24.0	1440	1.0045	4.5	5.0	180.85	0.91	0.0014	0.8069	1.71	2.64

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Table A1 e GRADING FOR T-K (B) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			100.0
$1^1/_2$ in	37.10		0.0	100.0
1 in	26.50		0.0	100.0
$^3/_4$ in	19.00		0.0	100.0
$^1/_2$ in	13.20	32.5	3.2	96.8
$^3/_8$ in	9.50	49.4	4.9	91.8
$^1/_4$ in	6.70	122.4	12.2	79.6
$^3/_{16}$ in	4.75	106.6	10.7	68.9
$^1/_8$ in	3.18	163.3	16.3	52.6

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	91.9	9.2	43.4
No. 14	1.18	15.1	13.2	30.2
No. 25	0.600	6.8	5.9	24.3
No. 36	0.425	1.7	1.4	22.9
No. 52	0.300	1.5	1.3	21.6
No. 72	0.212	1.5	1.3	20.3
No. 100	0.150	2.2	1.9	18.4
No. 200	0.075	4.6	4.0	14.4
Passing No. 200				
Total		454.1		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight 50g Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	Mt	R_a=R_h'+M_t-R_o'	K (%)
11:46	24.0	0.5	1.0130	13.0	13.5	147.28	0.909	0.0667	0.8069	10.21	13.92
	24.0	1.0	1.0110	11.0	11.5	155.18	0.909	0.0484	0.8069	8.21	11.19
	24.0	2.0	1.0100	10.0	10.5	159.13	0.909	0.0347	0.8069	7.21	9.83
	24.0	4.0	1.0090	9.0	9.5	163.08	0.91	0.0248	0.8069	6.21	8.47
	24.0	8.0	1.0086	8.6	9.1	164.66	0.91	0.0176	0.8069	5.81	7.92
	24.0	15.0	1.0080	8.0	8.5	167.03	0.91	0.0130	0.8069	5.21	7.10
	24.0	30.0	1.0070	7.0	7.5	170.98	0.91	0.0093	0.8069	4.21	5.74
	24.0	60.0	1.0068	6.8	7.3	171.77	0.91	0.0066	0.8069	4.01	5.47
	24.0	120	1.0058	5.8	6.3	175.72	0.91	0.0047	0.8069	3.01	4.10
	24.0	240	1.0052	5.2	5.7	178.09	0.91	0.0033	0.8069	2.41	3.28
	24.0	1440	1.0045	4.5	5.0	180.85	0.91	0.0014	0.8069	1.71	2.33

Table A1 d GRADING FOR T-K (B) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			100.0
$1^1/_2$ in	37.10		0.0	100.0
1 in	26.50		0.0	100.0
$^3/_4$ in	19.00		0.0	100.0
$^1/_2$ in	13.20	54.3	5.4	94.6
$^3/_8$ in	9.50	58.0	5.8	88.8
$^1/_4$ in	6.70	135.4	13.5	75.2
$^3/_{16}$ in	4.75	137.8	13.8	61.5
$^1/_8$ in	3.18	179.8	18.0	43.5

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	83.8	8.4	35.1
No. 14	1.18	13.1	9.2	25.9
No. 25	0.600	5.7	4.0	21.9
No. 36	0.425	1.6	1.1	20.7
No. 52	0.300	1.5	1.1	19.6
No. 72	0.212	1.7	1.2	18.5
No. 100	0.150	2.4	1.7	16.8
No. 200	0.075	3.4	2.4	14.4
Passing No. 200				
Total		565.2		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight 50g Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	Mt	R_a=R_h'+M_t-R_o'	K (%)
11:46	25.0	0.5	1.0145	14.5	15.0	141.35	0.888	0.0646	1.0358	11.94	13.17
	25.0	1.0	1.0128	12.8	13.3	148.07	0.888	0.0468	1.0358	10.24	11.29
	25.0	2.0	1.0106	10.6	11.1	156.76	0.888	0.0340	1.0358	8.04	8.86
	25.0	4.0	1.0095	9.5	10.0	161.10	0.89	0.0244	1.0358	6.94	7.65
	25.0	8.0	1.0085	8.5	9.0	165.05	0.89	0.0175	1.0358	5.94	6.55
	25.0	15.0	1.0080	8.0	8.5	167.03	0.89	0.0128	1.0358	5.44	6.00
	25.0	30.0	1.0075	7.5	8.0	169.00	0.89	0.0091	1.0358	4.94	5.44
	25.0	60.0	1.0070	7.0	7.5	170.98	0.89	0.0065	1.0358	4.44	4.89
	25.0	120	1.0060	6.0	6.5	174.93	0.89	0.0046	1.0358	3.44	3.79
	25.0	240	1.0055	5.5	6.0	176.90	0.89	0.0033	1.0358	2.94	3.24
	25.0	1440	1.0045	4.5	5.0	180.85	0.89	0.0014	1.0358	1.94	2.14

Table A2 a GRADING FOR T-K (SB) AFTER 55 BLOWS

Wet Sieving over 2.36mm BS Test Sieve.

Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
2½ in	63.00			
2 in	53.00			
1½ in	37.10			
1 in	26.50			
¾ in	19.00			100.0
½ in	13.20	27.8	2.8	97.2
⅜ in	9.50	62.8	6.3	90.9
¼ in	6.70	115.6	11.6	79.4
No. 7	4.75	104.5	10.4	68.9
No. 14	3.18	130.2	13.0	55.9
Passing No. 14		440.9		

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	92.1	9.2	46.7
No. 14	1.18	9.9	9.9	36.8
No. 25	0.600	5.1	5.1	31.7
No. 36	0.425	3.9	3.9	27.8
No. 52	0.300	2.7	2.7	25.1
No. 72	0.212	1.7	1.7	23.4
No. 100	0.150	1.8	1.7	21.7
No. 200	0.075	0.8	0.8	21.1
Passing No. 200				
Total		881.8		

Hydrometer test for material passing 2.36mm BS Test Sieve.

Total Dry Weight 50g Gs= 2.65

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, R1f	Transformed hydrometer reading, R1'	R1c=R1'+Cm	Effective depth, He (mm)	Viscosity, h (mPa.s)	D (mm)	Ws	Ry=Rc'+Ws-Rc'	R (%)
11:46	24.0	0.5	1.0172	17.2	17.7	130.80	0.909	0.04229	0.80369	14.38	21.83
	24.0	1.0	1.0159	15.9	16.4	135.66	0.909	0.03033	0.80369	13.15	19.96
	24.0	2.0	1.0148	14.8	15.3	140.17	0.909	0.02526	0.80369	12.33	18.23
	24.0	4.0	1.0135	13.5	14.0	145.30	0.91	0.02234	0.80369	10.75	16.19
	24.0	8.0	1.0127	12.7	13.2	148.55	0.91	0.01618	0.80369	9.88	15.00
	24.0	15.0	1.0118	11.8	12.3	152.17	0.91	0.01166	0.80369	8.97	13.63
	24.0	30.0	1.0109	10.9	11.4	155.93	0.91	0.00809	0.80369	8.12	12.32
	24.0	60.0	1.0100	10.0	10.5	159.13	0.91	0.00563	0.80369	7.23	10.98
	24.0	120	1.0096	9.6	10.1	160.71	0.91	0.00403	0.80369	6.81	10.35
	24.0	240	1.0092	9.2	9.7	162.29	0.91	0.00282	0.80369	6.41	9.73
	24.0	1440	1.0086	8.6	9.1	164.66	0.91	0.00113	0.80369	5.81	8.81

Table A2 b GRADING FOR T-K (SB) AFTER 25 BLOWS

Wet Sieving over 2.36mm BS Test Sieve.

Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
2½ in	63.00			
2 in	53.00			
1½ in	37.10			
1 in	26.50			
¾ in	19.00			100.0
½ in	13.20	29.8	3.0	97.0
⅜ in	9.50	107.4	10.7	86.3
¼ in	6.70	117.6	11.8	74.5
No. 7	4.75	96.3	9.6	64.9
No. 14	3.18	138.4	13.8	51.0
Passing No. 14		510.5		

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	80.3	8.3	42.8
No. 14	1.18	9.7	8.3	34.5
No. 25	0.600	5.1	4.8	30.1
No. 36	0.425	3.2	3.0	29.1
No. 52	0.300	2.3	2.1	28.0
No. 72	0.212	2.3	2.1	26.9
No. 100	0.150	2.3	2.3	25.0
No. 200	0.075	5.3	4.7	20.9
Passing No. 200				
Total		480.5		

Hydrometer test for material passing 2.36mm BS Test Sieve.

Total Dry Weight 50g Gs= 2.55

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, R1f	Transformed hydrometer reading, R1'	R1c=R1'+Cm	Effective depth, He (mm)	Viscosity, h (mPa.s)	D (mm)	Ws	Ry=Rc'+Ws-Rc'	R (%)
11:46	24.0	0.5	1.0180	18.0	18.5	127.33	0.909	0.04221	0.80369	15.22	22.46
	24.0	1.0	1.0162	16.2	16.7	134.64	0.909	0.03071	0.80369	13.40	19.33
	24.0	2.0	1.0150	15.0	15.5	139.38	0.909	0.02223	0.80369	12.23	16.42
	24.0	4.0	1.0136	13.6	14.1	144.91	0.91	0.02234	0.80369	10.81	14.54
	24.0	8.0	1.0126	12.6	13.1	148.86	0.91	0.01168	0.80369	9.81	13.19
	24.0	15.0	1.0120	12.0	12.5	151.23	0.91	0.01223	0.80369	9.23	12.38
	24.0	30.0	1.0115	11.5	12.0	153.20	0.91	0.00888	0.80369	8.75	11.75
	24.0	60.0	1.0104	10.4	10.9	157.55	0.91	0.00663	0.80369	7.61	10.23
	24.0	120	1.0100	10.0	10.5	159.13	0.91	0.00462	0.80369	7.23	9.69
	24.0	240	1.0094	9.4	9.9	161.50	0.91	0.00332	0.80369	6.61	8.89
	24.0	1440	1.0087	8.7	9.2	164.26	0.91	0.00113	0.80369	5.91	7.95

Table A2 c GRADING FOR T-K (SB) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	123.8	12.4	87.6
$^3/_8$ in	9.50	123.8	12.4	75.2
$^1/_4$ in	6.70	139.3	13.9	61.3
$^3/_{16}$ in	4.75	90.9	9.1	52.2
$^1/_8$ in	3.18	101.6	10.2	42.1

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	61.1	6.1	35.9
No. 14	1.18	8.5	6.1	29.8
No. 25	0.600	4.0	2.9	26.9
No. 36	0.425	1.3	0.9	26.0
No. 52	0.300	1.4	1.0	25.0
No. 72	0.212	1.4	1.0	24.0
No. 100	0.150	1.6	1.1	22.9
No. 200	0.075	6.2	4.5	18.4
Passing No. 200				
Total		579.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight 50g Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_c'$	K (%)
11:46	24.0	0.5	1.0180	18.0	18.5	127.53	0.909	0.0621	0.8069	15.21	17.16
	24.0	1.0	1.0165	16.5	17.0	133.45	0.909	0.0449	0.8069	13.71	15.47
	24.0	2.0	1.0150	15.0	15.5	139.38	0.909	0.0325	0.8069	12.21	13.77
	24.0	4.0	1.0135	13.5	14.0	145.30	0.91	0.0234	0.8069	10.71	12.08
	24.0	8.0	1.0129	12.9	13.4	147.67	0.91	0.0167	0.8069	10.11	11.40
	24.0	15.0	1.0126	12.6	13.1	148.86	0.91	0.0122	0.8069	9.81	11.06
	24.0	30.0	1.0118	11.8	12.3	152.02	0.91	0.0088	0.8069	9.01	10.16
	24.0	60.0	1.0110	11.0	11.5	155.18	0.91	0.0063	0.8069	8.21	9.26
	24.0	120	1.0100	10.0	10.5	159.13	0.91	0.0045	0.8069	7.21	8.13
	24.0	240	1.0095	9.5	10.0	161.10	0.91	0.0032	0.8069	6.71	7.57
	24.0	1440	1.0090	9.0	9.5	163.08	0.91	0.0013	0.8069	6.21	7.00

Table A2 d GRADING FOR T-K (SB) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	129.2	12.9	87.1
$^3/_8$ in	9.50	120.6	12.1	75.0
$^1/_4$ in	6.70	150.7	15.1	60.0
$^3/_{16}$ in	4.75	100.7	10.1	49.9
$^1/_8$ in	3.18	115.6	11.6	38.3

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	61.8	6.2	32.1
No. 14	1.18	8.4	5.4	26.8
No. 25	0.600	5.4	3.5	23.3
No. 36	0.425	2.1	1.3	22.0
No. 52	0.300	1.8	1.2	20.8
No. 72	0.212	1.8	1.2	19.6
No. 100	0.150	1.9	1.2	18.4
No. 200	0.075	5.9	3.8	14.6
Passing No. 200				
Total		616.8		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight 50g Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_c'$	K (%)
11:46	25.0	0.5	1.0155	15.5	16.0	137.40	0.888	0.0637	1.0358	12.94	13.86
	25.0	1.0	1.0140	14.0	14.5	143.33	0.888	0.0460	1.0358	11.44	12.26
	25.0	2.0	1.0126	12.6	13.1	148.86	0.888	0.0331	1.0358	10.04	10.76
	25.0	4.0	1.0118	11.8	12.3	152.02	0.89	0.0237	1.0358	9.24	9.90
	25.0	8.0	1.0112	11.2	11.7	154.39	0.89	0.0169	1.0358	8.64	9.26
	25.0	15.0	1.0110	11.0	11.5	155.18	0.89	0.0124	1.0358	8.44	9.04
	25.0	30.0	1.0104	10.4	10.9	157.55	0.89	0.0088	1.0358	7.84	8.40
	25.0	60.0	1.0100	10.0	10.5	159.13	0.89	0.0063	1.0358	7.44	7.97
	25.0	120	1.0090	9.0	9.5	163.08	0.89	0.0045	1.0358	6.44	6.90
	25.0	240	1.0085	8.5	9.0	165.05	0.89	0.0032	1.0358	5.94	6.36
	25.0	1440	1.0078	7.8	8.3	167.82	0.89	0.0013	1.0358	5.24	5.61

Table A3 a GRADING FOR JZ-Y (SB) AFTER 55 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	17.9	1.8	98.2
$^3/_8$ in	9.50	83.6	8.4	89.9
$^1/_4$ in	6.70	163.3	16.3	73.5
$^3/_{16}$ in	4.75	116.4	11.6	61.9
$^1/_8$ in	3.18	127.4	12.7	49.1
No. 7	2.36	60.5	6.1	43.1
No. 14	1.18	10.0	8.6	34.5
No. 25	0.600	5.0	4.3	30.2
No. 36	0.425	1.7	1.5	28.7
No. 52	0.300	1.7	1.5	27.2
NO. 72	0.212	1.8	1.6	25.7
No. 100	0.150	1.5	1.3	24.4
No. 200	0.075	6.1	5.3	19.1
Passing No. 200				
Total		508.6		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs=** 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	26.0	0.5	1.0155	15.5	16.0	137.40	0.867	0.0629	1.2755	13.18	17.85
	26.0	1.0	1.0144	14.4	14.9	141.75	0.867	0.0452	1.2755	12.08	16.36
	26.0	2.0	1.0134	13.4	13.9	145.70	0.867	0.0324	1.2755	11.08	15.00
	26.0	4.0	1.0125	12.5	13.0	149.37	0.87	0.0232	1.2755	10.15	13.74
	26.0	8.0	1.0117	11.7	12.2	152.41	0.87	0.0166	1.2755	9.38	12.70
	26.0	15.0	1.0110	11.0	11.5	155.18	0.87	0.0122	1.2755	8.68	11.75
	26.0	30.0	1.0104	10.4	10.9	157.55	0.87	0.0087	1.2755	8.08	10.94
	26.0	60.0	1.0097	9.7	10.2	160.31	0.87	0.0062	1.2755	7.38	9.99
	26.0	120	1.0093	9.3	9.8	161.89	0.87	0.0044	1.2755	6.98	9.45
	25.8	240	1.0087	8.7	9.2	164.26	0.87	0.0031	1.2267	6.33	8.57
	26.2	1440	1.0074	7.4	7.9	169.40	0.86	0.0013	1.3248	5.12	6.94

Table A3 b GRADING FOR JZ-Y (SB) AFTER 25 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 600g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	27.8	4.6	95.4
$^3/_8$ in	9.50	51.8	8.6	86.7
$^1/_4$ in	6.70	109.2	18.2	68.5
$^3/_{16}$ in		71.2	11.9	56.7
$^1/_8$ in	3.18	63.3	10.6	46.1
No. 7	2.36	35.0	5.8	40.3
No. 14	1.18	8.7	7.0	33.3
No. 25	0.600	6.1	4.9	28.4
No. 36	0.425	1.9	1.5	26.8
No. 52	0.300	1.8	1.5	25.4
NO. 72	0.212	1.9	1.5	23.8
No. 100	0.150	1.6	1.3	22.6
No. 200	0.075	5.5	4.4	18.1
Passing No. 200				
Total		323.3		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs=** 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	26.0	0.5	1.0157	15.6	16.1	136.81	0.867	0.0628	1.2755	13.33	16.88
	26.0	1.0	1.0136	13.6	14.1	144.83	0.867	0.0457	1.2755	11.30	14.31
	26.0	2.0	1.0127	12.7	13.2	148.39	0.867	0.0327	1.2755	10.39	13.16
	26.0	4.0	1.0121	12.1	12.6	150.83	0.87	0.0233	1.2755	9.78	12.38
	26.0	8.0	1.0115	11.5	12.0	153.20	0.87	0.0166	1.2755	9.18	11.62
	26.0	15.0	1.0109	10.9	11.4	155.57	0.87	0.0122	1.2755	8.58	10.86
	26.0	30.0	1.0102	10.2	10.7	158.34	0.87	0.0087	1.2755	7.88	9.97
	26.0	60.0	1.0095	9.5	10.0	161.10	0.87	0.0062	1.2755	7.18	9.09
	26.0	120	1.0090	9.0	9.5	163.08	0.87	0.0044	1.2755	6.68	8.46
	25.8	240	1.0084	8.4	8.9	165.45	0.87	0.0032	1.2267	6.03	7.63
	26.2	1440	1.0071	7.1	7.6	170.58	0.86	0.0013	1.3248	4.82	6.11

Table A3 c GRADING FOR JZ-Y (SB) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 900g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	46.2	5.1	94.9
$^3/_8$ in	9.50	113.5	12.6	82.3
$^1/_4$ in	6.70	166.7	18.5	63.7
$^3/_{16}$ in	4.75	107.5	11.9	51.8
$^1/_8$ in	3.18	97.8	10.9	40.9
No. 7	2.36	44.3	4.9	36.0
No. 14	1.18	8.1	5.8	30.2
No. 25	0.600	4.7	3.4	26.8
No. 36	0.425	1.6	1.2	25.6
No. 52	0.300	1.7	1.2	24.4
NO. 72	0.212	1.8	1.3	23.1
No. 100	0.150	3.2	2.3	20.8
No. 200	0.075	5.6	4.0	16.8
Passing No. 200				
Total		531.7		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs=** 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	26.0	0.5	1.0163	16.3	16.8	134.24	0.867	0.0622	1.2755	13.98	15.81
	26.0	1.0	1.0150	15.0	15.5	139.38	0.867	0.0448	1.2755	12.68	14.34
	26.0	2.0	1.0140	14.0	14.5	143.33	0.867	0.0321	1.2755	11.68	13.21
	26.0	4.0	1.0131	13.1	13.6	146.88	0.87	0.0230	1.2755	10.78	12.19
	26.0	8.0	1.0124	12.4	12.9	149.65	0.87	0.0164	1.2755	10.08	11.40
	26.0	15.0	1.0115	11.5	12.0	153.20	0.87	0.0121	1.2755	9.18	10.38
	26.0	30.0	1.0106	10.6	11.1	156.76	0.87	0.0087	1.2755	8.28	9.36
	26.0	60.0	1.0101	10.1	10.6	158.73	0.87	0.0062	1.2755	7.78	8.80
	26.0	120	1.0096	9.6	10.1	160.71	0.87	0.0044	1.2755	7.28	8.23
	25.8	240	1.0087	8.7	9.2	164.26	0.87	0.0031	1.2267	6.33	7.16
	26.2	1440	1.0076	7.6	8.1	168.61	0.86	0.0013	1.3248	5.32	6.02

Table A3 d GRADING FOR JZ-Y (SB) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 2000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	225.6	11.3	88.7
$^3/_8$ in	9.50	343.2	17.2	71.6
$^1/_4$ in	6.70	368.0	18.4	53.2
$^3/_{16}$ in	4.75	192.1	9.6	43.6
$^1/_8$ in	3.18	150.2	7.5	36.0
No. 7	2.36	64.2	3.2	32.8
No. 14	1.18	10.8	7.1	25.8
No. 25	0.600	3.0	2.0	23.8
No. 36	0.425	1.1	0.7	23.1
No. 52	0.300	1.4	0.9	22.2
NO. 72	0.212	1.8	1.2	21.0
No. 100	0.150	3.4	2.3	18.8
No. 200	0.075	5.6	3.7	15.1
Passing No. 200				
Total		1279.0		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs=** 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	26.0	0.5	1.0160	16.0	16.5	135.43	0.867	0.0625	1.2755	13.68	14.10
	26.0	1.0	1.0154	15.4	15.9	137.80	0.867	0.0446	1.2755	13.08	13.48
	26.0	2.0	1.0140	14.0	14.5	143.33	0.867	0.0321	1.2755	11.68	12.04
	26.0	4.0	1.0130	13.0	13.5	147.28	0.87	0.0230	1.2755	10.68	11.00
	26.0	8.0	1.0120	12.0	12.5	151.23	0.87	0.0165	1.2755	9.68	9.97
	26.0	15.0	1.0114	11.4	11.9	153.60	0.87	0.0122	1.2755	9.08	9.36
	26.0	30.0	1.0110	11.0	11.5	155.18	0.87	0.0086	1.2755	8.68	8.94
	26.0	60.0	1.0100	10.0	10.5	159.13	0.87	0.0062	1.2755	7.68	7.91
	26.0	120	1.0095	9.5	10.0	161.10	0.87	0.0044	1.2755	7.18	7.40
	25.8	240	1.0085	8.5	9.0	165.05	0.87	0.0032	1.2267	6.13	6.32
	26.2	1440	1.0075	7.5	8.0	169.00	0.86	0.0013	1.3248	5.22	5.39

Table A4 a GRADING FOR K-A (SB) AFTER 55 BLOWS.

Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	11.5	1.2	98.8
$^3/_8$ in	9.50	49.1	4.9	93.9
$^1/_4$ in	6.70	112.9	11.3	82.7
$^3/_{16}$ in	4.75	106.7	10.7	72.0
$^1/_8$ in	3.18	115.9	11.6	60.4
No. 7	2.36	49.6	5.0	55.4
No. 14	1.18	4.2	4.6	50.8
No. 25	0.600	3.2	3.6	47.3
No. 36	0.425	1.8	1.9	45.3
No. 52	0.300	2.2	2.4	42.9
NO. 72	0.212	2.5	2.8	40.1
No. 100	0.150	2.2	2.4	37.7
No. 200	0.075	4.9	5.5	32.2
Passing No. 200				
Total		396.0		

Hydrometer test for material passing 2.36mm BS Test Seive.

Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	27.2	0.5	1.0195	19.5	20.0	121.60	0.843	0.0584	1.5774	17.48	30.43
	27.2	1.0	1.0180	18.0	18.5	127.53	0.843	0.0423	1.5774	15.98	27.82
	27.2	2.0	1.0170	17.0	17.5	131.48	0.843	0.0304	1.5774	14.98	26.08
	27.2	4.0	1.0162	16.2	16.7	134.64	0.84	0.0217	1.5774	14.18	24.68
	27.2	8.0	1.0151	15.1	15.6	138.98	0.84	0.0156	1.5774	13.08	22.77
	27.2	15.0	1.0145	14.5	15.0	141.35	0.84	0.0115	1.5774	12.48	21.72
	27.2	30.0	1.0137	13.7	14.2	144.51	0.84	0.0082	1.5774	11.68	20.33
	26.8	60.0	1.0131	13.1	13.6	146.88	0.85	0.0059	1.4750	10.98	19.11
	26.4	120	1.0126	12.6	13.1	148.86	0.86	0.0042	1.3744	10.37	18.06
	26.0	240	1.0120	12.0	12.5	151.23	0.87	0.0030	1.2755	9.68	16.85
	27.0	1440	1.0100	10.0	10.5	159.13	0.85	0.0012	1.5260	7.93	13.80

Table A4 b GRADING FOR K-A (SB) AFTER 25 BLOWS.

Wet Seiving over 2.36mm BS Test Seive.

Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	26.3	2.6	97.4
$^3/_8$ in	9.50	47.6	4.8	92.6
$^1/_4$ in	6.70	150.2	15.0	77.6
$^3/_{16}$ in	4.75	97.0	9.7	67.9
$^1/_8$ in	3.18	107.8	10.8	57.1
No. 7	2.36	46.2	4.6	52.5
No. 14	1.18	5.2	5.4	47.1
No. 25	0.600	3.1	3.2	43.8
No. 36	0.425	1.5	1.6	42.2
No. 52	0.300	1.9	2.0	40.2
NO. 72	0.212	2.3	2.4	37.8
No. 100	0.150	1.9	2.0	35.8
No. 200	0.075	4.8	5.1	30.8
Passing No. 200				
Total		428.8		

Hydrometer test for material passing 2.36mm BS Test Seive.

Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	27.2	0.5	1.0200	20.0	20.5	119.63	0.843	0.0579	1.5774	17.98	29.66
	27.2	1.0	1.0186	18.6	19.1	125.16	0.843	0.0419	1.5774	16.58	27.35
	27.2	2.0	1.0174	17.4	17.9	129.90	0.843	0.0302	1.5774	15.38	25.37
	27.2	4.0	1.0165	16.5	17.0	133.45	0.84	0.0216	1.5774	14.48	23.89
	27.2	8.0	1.0156	15.6	16.1	137.01	0.84	0.0155	1.5774	13.58	22.40
	27.2	15.0	1.0150	15.0	15.5	139.38	0.84	0.0114	1.5774	12.98	21.41
	27.2	30.0	1.0140	14.0	14.5	143.33	0.84	0.0082	1.5774	11.98	19.76
	26.8	60.0	1.0134	13.4	13.9	145.70	0.85	0.0059	1.4750	11.28	18.60
	26.4	120	1.0127	12.7	13.2	148.46	0.86	0.0042	1.3744	10.47	17.28
	26.0	240	1.0121	12.1	12.6	150.83	0.87	0.0030	1.2755	9.78	16.13
	27.0	1440	1.0100	10.0	10.5	159.13	0.85	0.0012	1.5260	7.93	13.08

Table A4 c GRADING FOR K-A (SB) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive.

Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	31.6	3.2	96.8
$^3/_8$ in	9.50	67.8	6.8	90.1
$^1/_4$ in	6.70	134.7	13.5	76.6
$^3/_{16}$ in	4.75	114.8	11.5	65.1
$^1/_8$ in	3.18	122.7	12.3	52.8
No. 7	2.36	50.4	5.0	47.8
No. 14	1.18	5.2	5.0	42.8
No. 25	0.600	2.8	2.6	40.2
No. 36	0.425	1.4	1.3	38.9
No. 52	0.300	1.8	1.7	37.2
NO. 72	0.212	2.1	2.0	35.1
No. 100	0.150	1.8	1.8	33.3
No. 200	0.075	4.6	4.3	29.0
Passing No. 200				
Total		471.6		

Hydrometer test for material passing 2.36mm BS Test Seive.

Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_c=R_h'+M_t-R_o'$	K (%)
11:46	27.2	0.5	1.0200	20.0	20.5	119.63	0.843	0.0579	1.5774	17.98	27.01
	27.2	1.0	1.0187	18.7	19.2	124.76	0.843	0.0418	1.5774	16.68	25.05
	27.2	2.0	1.0176	17.6	18.1	129.11	0.843	0.0301	1.5774	15.58	23.40
	27.2	4.0	1.0165	16.5	17.0	133.45	0.84	0.0216	1.5774	14.48	21.75
	27.2	8.0	1.0160	16.0	16.5	135.43	0.84	0.0154	1.5774	13.98	21.00
	27.2	15.0	1.0150	15.0	15.5	139.38	0.84	0.0114	1.5774	12.98	19.50
	27.2	30.0	1.0142	14.2	14.7	142.54	0.84	0.0082	1.5774	12.18	18.29
	26.8	60.0	1.0135	13.5	14.0	145.30	0.85	0.0059	1.4750	11.38	17.09
	26.4	120	1.0130	13.0	13.5	147.28	0.86	0.0042	1.3744	10.77	16.19
	26.0	240	1.0121	12.1	12.6	150.83	0.87	0.0030	1.2755	9.78	14.69
	27.0	1440	1.0102	10.2	10.7	158.34	0.85	0.0012	1.5260	8.13	12.21

Table A4 d GRADING FOR K-A (SB) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive.

Total Dry Weight (g) 1983.3

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	285.3	14.4	85.6
$^3/_8$ in	9.50	141.4	7.1	78.5
$^1/_4$ in	6.70	268.8	13.6	64.9
$^3/_{16}$ in	4.75	192.5	9.7	55.2
$^1/_8$ in	3.18	196.8	9.9	45.3
No. 7	2.36	64.0	3.2	42.1
No. 14	1.18	3.5	2.9	39.1
No. 25	0.600	2.2	1.9	37.3
No. 36	0.425	1.4	1.2	36.1
No. 52	0.300	1.9	1.6	34.5
NO. 72	0.212	2.4	2.0	32.5
No. 100	0.150	2.3	1.9	30.5
No. 200	0.075	6.0	5.1	25.5
Passing No. 200				
Total		54.7		

Hydrometer test for material passing 2.36mm BS Test Seive.

Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_c=R_h'+M_t-R_o'$	K (%)
11:46	29.2	0.5	1.0190	19.0	19.5	123.58	0.806	0.0575	2.1148	17.51	23.17
	29.2	1.0	1.0176	17.6	18.1	129.11	0.806	0.0416	2.1148	16.11	21.32
	29.2	2.0	1.0160	16.0	16.5	135.43	0.806	0.0301	2.1148	14.51	19.21
	29.2	4.0	1.0146	14.6	15.1	140.96	0.81	0.0217	2.1148	13.11	17.35
	29.2	8.0	1.0138	13.8	14.3	144.12	0.81	0.0155	2.1148	12.31	16.29
	29.2	15.0	1.0130	13.0	13.5	147.28	0.81	0.0115	2.1148	11.51	15.24
	29.2	30.0	1.0121	12.1	12.6	150.83	0.81	0.0082	2.1148	10.61	14.04
	29.6	60.0	1.0112	11.2	11.7	154.39	0.80	0.0058	2.2274	9.83	13.00
	29.6	120	1.0105	10.5	11.0	157.15	0.80	0.0042	2.2274	9.13	12.08
	30.2	240	1.0095	9.5	10.0	161.10	0.79	0.0030	2.3996	8.30	10.98
	30.8	1440	1.0085	8.5	9.0	165.05	0.78	0.0012	2.5756	7.48	9.89

Table A5 a GRADING FOR L-BP (SB) AFTER 55 BLOWS.

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
9	53.00			100.0
$1^1/_2$ in	37.10		0.0	100.0
1 in	26.50		0.0	100.0
$^3/_4$ in	19.00		0.0	100.0
$^1/_2$ in	13.20	34.6	3.5	96.5
$^3/_8$ in	9.50	50.9	5.1	91.4
$^1/_4$ in	6.70	104.6	10.5	81.0
$^3/_{16}$ in	4.75	85.3	8.5	72.5
$^1/_8$ in	3.18	116.7	11.7	60.8

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	71.5	7.2	53.6
No. 14	1.18	9.3	10.0	43.7
No. 25	0.600	3.5	3.8	39.9
No. 36	0.425	1.1	1.2	38.7
No. 52	0.300	1.0	1.1	37.7
No. 72	0.212	1.0	1.1	36.6
No. 100	0.150	0.8	0.9	35.7
No. 200	0.075	2.2	2.3	33.4
Passing No. 200				
Total		392.1		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight **50g** **Gs=** **2.75**

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	24.0	0.5	1.0218	21.8	22.3	112.65	0.909	0.0584	0.8069	18.97	31.96
	24.0	1.0	1.0204	20.4	20.9	118.20	0.909	0.0423	0.8069	17.57	29.59
	24.0	2.0	1.0191	19.1	19.6	123.32	0.909	0.0305	0.8069	16.27	27.41
	24.0	4.0	1.0178	17.8	18.3	128.43	0.91	0.0220	0.8069	14.98	25.23
	24.0	8.0	1.0164	16.4	16.9	133.85	0.91	0.0159	0.8069	13.61	22.92
	24.0	15.0	1.0152	15.2	15.7	138.59	0.91	0.0118	0.8069	12.41	20.90
	24.0	30.0	1.0142	14.2	14.7	142.54	0.91	0.0085	0.8069	11.41	19.22
	24.0	60.0	1.0134	13.4	13.9	145.70	0.91	0.0061	0.8069	10.61	17.87
	24.0	120	1.0125	12.5	13.0	149.25	0.91	0.0043	0.8069	9.71	16.35
	24.0	240	1.0117	11.7	12.2	152.41	0.91	0.0031	0.8069	8.91	15.00
	24.0	1440	1.0090	9.0	9.5	163.08	0.91	0.0013	0.8069	6.21	10.46

Table A5 b GRADING FOR L-BP (SB) AFTER 25 BLOWS.

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			100.0
$1^1/_2$ in	37.10		0.0	100.0
1 in	26.50		0.0	100.0
$^3/_4$ in	19.00		0.0	100.0
$^1/_2$ in	13.20	41.9	4.2	95.8
$^3/_8$ in	9.50	79.5	7.9	87.9
$^1/_4$ in	6.70	104.8	10.5	77.4
$^3/_{16}$ in	4.75	87.4	8.7	68.6
$^1/_8$ in	3.18	122.4	12.2	56.4

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	66.7	6.7	49.7
No. 14	1.18	7.4	7.4	42.4
No. 25	0.600	3.3	3.3	39.1
No. 36	0.425	1.1	1.0	38.0
No. 52	0.300	1.0	1.0	37.0
No. 72	0.212	1.1	1.0	36.0
No. 100	0.150	0.9	0.9	35.1
No. 200	0.075	2.3	2.3	32.8
Passing No. 200				
Total		435.9		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight **50g** **Gs=** **2.75**

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	24.0	0.5	1.0225	22.5	23.0	109.87	0.909	0.0576	0.8069	19.68	30.74
	24.0	1.0	1.0209	20.9	21.4	116.19	0.909	0.0419	0.8069	18.08	28.24
	24.0	2.0	1.0192	19.2	19.7	122.79	0.909	0.0305	0.8069	16.41	25.63
	24.0	4.0	1.0180	18.0	18.5	127.53	0.91	0.0220	0.8069	15.21	23.75
	24.0	8.0	1.0165	16.5	17.0	133.45	0.91	0.0159	0.8069	13.71	21.41
	24.0	15.0	1.0155	15.5	16.0	137.40	0.91	0.0118	0.8069	12.71	19.85
	24.0	30.0	1.0140	14.0	14.5	143.33	0.91	0.0085	0.8069	11.21	17.51
	24.0	60.0	1.0135	13.5	14.0	145.30	0.91	0.0061	0.8069	10.71	16.72
	24.0	120	1.0126	12.6	13.1	148.86	0.91	0.0043	0.8069	9.81	15.32
	24.0	240	1.0118	11.8	12.3	152.02	0.91	0.0031	0.8069	9.01	14.07
	24.0	1440	1.0090	9.0	9.5	163.08	0.91	0.0013	0.8069	6.21	9.70

Table A5 c GRADING FOR L-BP(SB) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight **1000g**

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			100.0
$1^1/_2$ in	37.10		0.0	100.0
1 in	26.50		0.0	100.0
$^3/_4$ in	19.00		0.0	100.0
$^1/_2$ in	13.20	49.2	4.9	95.1
$^3/_8$ in	9.50	94.2	9.4	85.7
$^1/_4$ in	6.70	107.5	10.7	74.9
$^3/_{16}$ in	4.75	95.6	9.6	65.4
$^1/_8$ in	3.18	130.7	13.1	52.3
No. 7	2.36	61.8	6.2	46.1
No. 14	1.18	8.3	7.6	38.5
No. 25	0.600	3.1	2.8	35.6
No. 36	0.425	0.9	0.9	34.8
No. 52	0.300	0.9	0.8	33.9
No. 72	0.212	0.9	0.9	33.1
No. 100	0.150	0.9	0.8	32.2
No. 200	0.075	2.1	1.9	30.3
Passing No. 200				
Total		477.1		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight **50g** **Gs=** **2.75**

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h·(mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	24.0	0.5	1.0226	22.6	23.1	109.53	0.909	0.0576	0.8069	19.76	28.63
	24.0	1.0	1.0212	21.2	21.7	114.96	0.909	0.0417	0.8069	18.39	26.64
	24.0	2.0	1.0196	19.6	20.1	121.21	0.909	0.0303	0.8069	16.81	24.35
	24.0	4.0	1.0182	18.2	18.7	126.74	0.91	0.0219	0.8069	15.41	22.32
	24.0	8.0	1.0170	17.0	17.5	131.48	0.91	0.0158	0.8069	14.21	20.58
	24.0	15.0	1.0160	16.0	16.5	135.43	0.91	0.0117	0.8069	13.21	19.13
	24.0	30.0	1.0146	14.6	15.1	140.96	0.91	0.0084	0.8069	11.81	17.11
	24.0	60.0	1.0137	13.7	14.2	144.51	0.91	0.0060	0.8069	10.91	15.80
	24.0	120	1.0130	13.0	13.5	147.28	0.91	0.0043	0.8069	10.21	14.79
	24.0	240	1.0120	12.0	12.5	151.23	0.91	0.0031	0.8069	9.21	13.34
	24.0	1440	1.0090	9.0	9.5	163.08	0.91	0.0013	0.8069	6.21	8.99

Table A5 d GRADING FOR L-BP (SB) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight **1000g**

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			100.0
$1^1/_2$ in	37.10		0.0	100.0
1 in	26.50		0.0	100.0
$^3/_4$ in	19.00		0.0	100.0
$^1/_2$ in	13.20	85.3	8.5	91.5
$^3/_8$ in	9.50	97.9	9.8	81.7
$^1/_4$ in	6.70	115.5	11.6	70.1
$^3/_{16}$ in	4.75	106.5	10.7	59.5
$^1/_8$ in	3.18	129.3	12.9	46.5
No. 7	2.36	63.5	6.3	40.2
No. 14	1.18	6.7	5.4	34.8
No. 25	0.600	2.8	2.2	32.6
No. 36	0.425	0.9	0.7	31.8
No. 52	0.300	0.9	0.8	31.1
No. 72	0.212	1.0	0.8	30.3
No. 100	0.150	0.9	0.7	29.6
No. 200	0.075	2.2	1.8	27.8
Passing No. 200				
Total		534.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight **50g** **Gs=** **2.75**

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	25.0	0.5	1.0232	23.2	23.7	106.83	0.888	0.0562	1.0358	20.68	26.12
	25.0	1.0	1.0218	21.8	22.3	112.44	0.888	0.0407	1.0358	19.26	24.33
	25.0	2.0	1.0204	20.4	20.9	118.05	0.888	0.0295	1.0358	17.84	22.53
	25.0	4.0	1.0190	19.0	19.5	123.58	0.89	0.0214	1.0358	16.44	20.77
	25.0	8.0	1.0176	17.6	18.1	129.11	0.89	0.0154	1.0358	15.04	19.00
	25.0	15.0	1.0165	16.5	17.0	133.45	0.89	0.0115	1.0358	13.94	17.61
	25.0	30.0	1.0150	15.0	15.5	139.38	0.89	0.0083	1.0358	12.44	15.71
	25.0	60.0	1.0142	14.2	14.7	142.54	0.89	0.0059	1.0358	11.64	14.70
	25.0	120	1.0135	13.5	14.0	145.30	0.89	0.0042	1.0358	10.94	13.82
	25.0	240	1.0124	12.4	12.9	149.65	0.89	0.0030	1.0358	9.84	12.43
	25.0	1440	1.0095	9.5	10.0	161.10	0.89	0.0013	1.0358	6.94	8.76

Table A6 a GRADING FOR GR (B) AFTER 55 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	148.7	9.9	90.1
$^3/_8$ in	9.50	109.1	7.3	82.8
$^1/_4$ in	6.70	149.7	10.0	72.8
$^3/_{16}$ in	4.75	128.1	8.5	64.3
$^1/_8$ in	3.18	228.8	15.3	49.0
No. 7	2.36	149.9	10.0	39.0
No. 14	1.18	9.9	7.7	31.3
No. 25	0.600	6.2	4.8	26.5
No. 36	0.425	2.0	1.5	25.0
No. 52	0.300	1.9	1.5	23.5
NO. 72	0.212	1.9	1.5	22.1
No. 100	0.150	1.6	1.3	20.8
No. 200	0.075	9.1	7.1	13.7
Passing No. 200				
Total		764.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_o=R_h'+M_t-R_o'$	K (%)
10:43	27.4	0.5	1.0120	12.0	12.5	151.23	0.839	0.0650	1.6292	10.03	12.29
	27.4	1.0	1.0105	10.5	11.0	157.15	0.839	0.0468	1.6292	8.53	10.45
	27.4	2.0	1.0090	9.0	9.5	163.08	0.839	0.0337	1.6292	7.03	8.62
	27.4	4.0	1.0080	8.0	8.5	167.03	0.84	0.0241	1.6292	6.03	7.39
	27.4	8.0	1.0072	7.2	7.7	170.19	0.84	0.0172	1.6292	5.23	6.41
	27.4	15.0	1.0064	6.4	6.9	173.35	0.84	0.0127	1.6292	4.43	5.43
	27.0	30.0	1.0058	5.8	6.3	175.72	0.85	0.0091	1.5260	3.73	4.57
	27.0	60.0	1.0050	5.0	5.5	178.88	0.85	0.0065	1.5260	2.93	3.59
	26.2	120	1.0046	4.6	5.1	180.46	0.86	0.0046	1.3248	2.32	2.85
	27.6	240	1.0042	4.2	4.7	182.04	0.84	0.0032	1.6814	2.28	2.80
	28.6	1440	1.0035	3.5	4.0	184.80	0.82	0.0013	1.9490	1.85	2.27

Table A6 b GRADING FOR GR (B) AFTER 25 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	173.4	11.6	88.4
$^3/_8$ in	9.50	104.3	7.0	81.5
$^1/_4$ in	6.70	146.3	9.8	71.7
$^3/_{16}$ in	4.75	146.8	9.8	61.9
$^1/_8$ in	3:18	234.5	15.6	46.3
No. 7	2.36	154.5	10.3	36.0
No. 14	1.18	13.8	9.9	26.1
No. 25	0.600	5.1	3.7	22.4
No. 36	0.425	1.3	1.0	21.5
No. 52	0.300	1.3	0.9	20.6
NO. 72	0.212	1.3	0.9	19.6
No. 100	0.150	1.4	1.0	18.7
No. 200	0.075	9.5	6.8	11.8
Passing No. 200				
Total		805.3		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_o=R_h'+M_t-R_o'$	K (%)
10:48	27.4	0.5	1.0110	11.0	11.5	155.18	0.839	0.0658	1.6292	9.03	10.22
	27.4	1.0	1.0096	9.6	10.1	160.71	0.839	0.0474	1.6292	7.63	8.63
	27.4	2.0	1.0084	8.4	8.9	165.45	0.839	0.0340	1.6292	6.43	7.27
	27.4	4.0	1.0076	7.6	8.1	168.61	0.84	0.0243	1.6292	5.63	6.37
	27.4	8.0	1.0070	7.0	7.5	170.98	0.84	0.0173	1.6292	5.03	5.69
	27.4	15.0	1.0065	6.5	7.0	172.95	0.84	0.0127	1.6292	4.53	5.12
	27.0	30.0	1.0058	5.8	6.3	175.72	0.85	0.0091	1.5260	3.73	4.22
	27.0	60.0	1.0052	5.2	5.7	178.09	0.85	0.0065	1.5260	3.13	3.54
	26.2	120	1.0045	4.5	5.0	180.85	0.86	0.0047	1.3248	2.22	2.52
	27.6	240	1.0044	4.4	4.9	181.25	0.84	0.0032	1.6814	2.48	2.81
	27.6	1440	1.0041	4.1	4.6	182.43	0.84	0.0013	1.6814	2.18	2.47

Table A6 c GRADING FOR GR (B) AFTER 10 BLOWS.

Wet Sieving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
2½ in	63.00			
2 in	53.00			
1½ in	37.10			
1 in	26.50			
¾ in	19.00			100.0
½ in	13.20	168.0	11.2	88.8
⅜ in	9.50	113.9	7.6	81.2
¼ in	6.70	175.9	11.7	69.5
5/32 in	4.75	154.9	10.3	59.2
⅛ in	3.18	254.4	17.0	42.2

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	167.4	11.2	31.0
No. 14	1.18	11.4	7.1	24.0
No. 25	0.600	4.2	2.8	21.2
No. 36	0.425	1.4	0.9	20.2
No. 52	0.300	1.5	1.0	19.2
NO. 72	0.212	1.7	1.2	18.1
No. 100	0.150	1.8	1.2	16.8
No. 200	0.075	8.4	5.6	11.2
Passing No. 200				
Total		867.0		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.55

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, Rif	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	Mt	$R_c=R_h'+M_t-R_c'$	K (%)
10:37	27.4	0.5	1.0120	12.0	12.5	151.23	0.839	0.0650	1.6292	10.03	9.77
	27.4	1.0	1.0110	11.0	11.5	155.18	0.839	0.0463	1.6292	9.03	8.80
	27.4	2.0	1.0095	9.5	10.0	161.10	0.839	0.0335	1.6292	7.53	7.34
	27.4	4.0	1.0083	8.3	8.8	165.84	0.84	0.0241	1.6292	6.33	6.17
	27.4	8.0	1.0076	7.6	8.1	168.61	0.84	0.0172	1.6292	5.63	5.48
	27.4	15.0	1.0070	7.0	7.5	170.98	0.84	0.0126	1.6292	5.03	4.90
	27.0	30.0	1.0060	6.0	6.5	174.93	0.85	0.0091	1.5260	3.93	3.83
	27.0	60.0	1.0057	5.7	6.2	176.11	0.85	0.0064	1.5260	3.63	3.53
	26.2	120	1.0048	4.8	5.3	179.67	0.86	0.0046	1.3248	2.52	2.46
	27.6	240	1.0044	4.4	4.9	181.25	0.84	0.0032	1.6814	2.48	2.42
	28.6	1440	1.0038	3.8	4.3	183.62	0.82	0.0013	1.9400	2.15	2.09

Table A6 d GRADING FOR GR (B) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
2½ in	63.00			
2 in	53.00			
1½ in	37.10			
1 in	26.50			
¾ in	19.00			100.0
½ in	13.20	192.9	12.9	87.1
⅜ in	9.50	154.2	10.3	76.9
¼ in	6.70	153.7	10.2	66.6
5/32 in	4.75	160.0	10.7	55.9
⅛ in	3.18	292.7	19.5	36.4

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	175.2	11.7	24.8
No. 14	1.18	8.5	4.2	20.5
No. 25	0.600	3.1	1.5	19.0
No. 36	0.425	1.2	0.6	18.4
No. 52	0.300	1.4	0.7	17.7
NO. 72	0.212	1.7	0.8	16.8
No. 100	0.150	1.6	0.8	16.1
No. 200	0.075	11.8	5.9	10.2
Passing No. 200				
Total		953.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, Rif	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	Mt	$R_c=R_h'+M_t-R_c'$	K (%)
10:08am	27.4	0.5	1.0135	13.5	14.0	145.30	0.839	0.0637	1.6292	11.53	8.99
	27.4	1.0	1.0115	11.5	12.0	153.08	0.839	0.0462	1.6292	9.56	7.45
	27.4	2.0	1.0097	9.7	10.2	160.31	0.839	0.0334	1.6292	7.73	6.02
	27.4	4.0	1.0090	9.0	9.5	163.08	0.84	0.0239	1.6292	7.03	5.48
	27.4	8.0	1.0084	8.4	8.9	165.45	0.84	0.0170	1.6292	6.43	5.01
	27.4	15.0	1.0077	7.7	8.2	168.21	0.84	0.0125	1.6292	5.73	4.47
	27.0	30.0	1.0072	7.2	7.7	170.19	0.85	0.0089	1.5260	5.13	4.00
	27.0	60.0	1.0068	6.8	7.3	171.77	0.85	0.0064	1.5260	4.73	3.68
	26.2	120	1.0064	6.4	6.9	173.35	0.86	0.0046	1.3248	4.12	3.21
	27.6	240	1.0060	6.0	6.5	174.93	0.84	0.0032	1.6814	4.08	3.18
	27.6	1440	1.0057	5.7	6.2	176.11	0.84	0.0013	1.6814	3.78	2.95

Table A7 a GRADING FOR A-N (SB) AFTER 55 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	126.1	8.4	91.6
$^3/_8$ in	9.50	150.9	10.1	81.5
$^1/_4$ in	6.70	146.5	9.8	71.8
$^3/_{16}$ in	4.75	89.4	6.0	65.8
$^1/_8$ in	3.18	105.8	7.1	58.8
No. 7	2.36	73.0	4.9	53.9
No. 14	1.18	7.0	7.5	46.4
No. 25	0.600	6.9	7.4	39.0
No. 36	0.425	2.8	3.0	36.0
No. 52	0.300	2.5	2.7	33.3
NO. 72	0.212	2.1	2.2	31.1
No. 100	0.150	1.6	1.7	29.4
No. 200	0.075	4.3	4.6	24.7
Passing No. 200				
Total		618.8		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_c=R_h'+M_t-R_t'$	K (%)
1:21	27.4	0.5	1.0160	16.0	16.5	135.43	0.839	0.0615	1.6292	14.03	23.77
	27.4	1.0	1.0148	14.8	15.3	140.17	0.839	0.0442	1.6292	12.83	21.73
	27.4	2.0	1.0140	14.0	14.5	143.33	0.839	0.0316	1.6292	12.03	20.38
	27.4	4.0	1.0131	13.1	13.6	146.88	0.84	0.0226	1.6292	11.13	18.85
	27.4	8.0	1.0124	12.4	12.9	149.65	0.84	0.0162	1.6292	10.43	17.67
	27.4	15.0	1.0116	11.6	12.1	152.81	0.84	0.0119	1.6292	9.63	16.31
	27.0	30.0	1.0108	10.8	11.3	155.97	0.85	0.0086	1.5260	8.73	14.78
	27.0	60.0	1.0100	10.0	10.5	159.13	0.85	0.0061	1.5260	7.93	13.43
	26.2	120	1.0094	9.4	9.9	161.50	0.86	0.0044	1.3248	7.12	12.07
	27.6	240	1.0090	9.0	9.5	163.08	0.84	0.0031	1.6814	7.08	12.00
	30.8	1440	1.0074	7.4	7.9	169.40	0.78	0.0012	2.5756	6.38	10.80

Table A7 b GRADING FOR A-N (SB) AFTER 25 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	270.8	18.1	81.9
$^3/_8$ in	9.50	198.2	13.2	68.7
$^1/_4$ in	6.70	137.8	9.2	59.5
$^3/_{16}$ in	4.75	74.9	5.0	54.6
$^1/_8$ in	3.18	87.9	5.9	48.7
No. 7	2.36	59.6	4.0	44.7
No. 14	1.18	6.4	5.7	39.0
No. 25	0.600	6.6	5.9	33.1
No. 36	0.425	2.7	2.4	30.7
No. 52	0.300	2.4	2.1	28.6
NO. 72	0.212	2.0	1.8	26.8
No. 100	0.150	2.2	2.0	24.9
No. 200	0.075	4.9	4.4	20.5
Passing No. 200				
Total		769.6		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_c=R_h'+M_t-R_t'$	K (%)
11:46	27.4	0.5	1.0155	15.5	16.0	137.40	0.839	0.0619	1.6292	13.53	19.01
	27.4	1.0	1.0143	14.3	14.8	142.14	0.839	0.0445	1.6292	12.33	17.32
	27.4	2.0	1.0132	13.2	13.7	146.49	0.839	0.0320	1.6292	11.23	15.78
	27.4	4.0	1.0126	12.6	13.1	148.86	0.84	0.0228	1.6292	10.63	14.93
	27.4	8.0	1.0120	12.0	12.5	151.23	0.84	0.0162	1.6292	10.03	14.09
	27.4	15.0	1.0110	11.0	11.5	155.18	0.84	0.0120	1.6292	9.03	12.68
	27.0	30.0	1.0100	10.0	10.5	159.13	0.85	0.0086	1.5260	7.93	11.13
	27.0	60.0	1.0097	9.7	10.2	160.31	0.85	0.0061	1.5260	7.63	10.71
	26.2	120	1.0090	9.0	9.5	163.08	0.86	0.0044	1.3248	6.72	9.45
	27.6	240	1.0086	8.6	9.1	164.66	0.84	0.0031	1.6814	6.68	9.39
	30.8	1440	1.0070	7.0	7.5	170.98	0.78	0.0012	2.5756	5.98	8.39

Table A7 c GRADING FOR A-N (SB) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	323.9	21.6	78.4
$^3/_8$ in	9.50	257.6	17.2	61.2
$^1/_4$ in	6.70	198.3	13.2	48.0
$^3/_{16}$ in	4.75	92.0	6.1	41.9
$^1/_8$ in	3.18	100.0	6.7	35.2
No. 7	2.36	76.3	5.1	30.1
No. 14	1.18	6.1	3.7	26.4
No. 25	0.600	6.3	3.8	22.7
No. 36	0.425	2.8	1.7	21.0
No. 52	0.300	2.6	1.5	19.4
NO. 72	0.212	2.2	1.3	18.1
No. 100	0.150	1.4	0.8	17.3
No. 200	0.075	3.3	2.0	15.3
Passing No. 200				
Total		971.8		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_o=R_h'+M_t-R_o'$	K (%)
10:31	27.4	0.5	1.0170	17.0	17.5	131.48	0.839	0.0606	1.6292	15.03	14.22
	27.4	1.0	1.0162	16.2	16.7	134.64	0.839	0.0433	1.6292	14.23	13.46
	27.4	2.0	1.0151	15.1	15.6	138.98	0.839	0.0311	1.6292	13.13	12.42
	27.4	4.0	1.0140	14.0	14.5	143.33	0.84	0.0224	1.6292	12.03	11.38
	27.4	8.0	1.0126	12.6	13.1	148.86	0.84	0.0161	1.6292	10.63	10.06
	27.4	15.0	1.0120	12.0	12.5	151.23	0.84	0.0119	1.6292	10.03	9.49
	27.0	30.0	1.0110	11.0	11.5	155.18	0.85	0.0085	1.5260	8.93	8.44
	27.0	60.0	1.0104	10.4	10.9	157.55	0.85	0.0061	1.5260	8.33	7.88
	26.2	120	1.0096	9.6	10.1	160.71	0.86	0.0044	1.3248	7.32	6.93
	27.6	240	1.0090	9.0	9.5	163.08	0.84	0.0031	1.6814	7.08	6.70
	30.8	1440	1.0080	8.0	8.5	167.03	0.78	0.0012	2.5756	6.98	6.60

Table A7 d GRADING FOR A-N (SB) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	367.6	24.5	75.5
$^3/_8$ in	9.50	220.3	14.7	60.8
$^1/_4$ in	6.70	194.5	13.0	47.8
$^3/_{16}$ in	4.75	84.7	5.6	42.2
$^1/_8$ in	3.18	113.8	7.6	34.6
No. 7	2.36	72.5	4.8	29.8
No. 14	1.18	7.3	4.4	25.4
No. 25	0.600	6.7	4.0	21.4
No. 36	0.425	2.8	1.7	19.8
No. 52	0.300	2.4	1.4	18.3
NO. 72	0.212	2.0	1.2	17.1
No. 100	0.150	2.5	1.5	15.7
No. 200	0.075	4.5	2.7	13.0
Passing No. 200				
Total		980.9		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_o=R_h'+M_t-R_o'$	K (%)
9:54	27.4	0.5	1.0150	15.0	15.5	139.38	0.839	0.0624	1.6292	13.03	12.20
	27.4	1.0	1.0140	14.0	14.5	143.33	0.839	0.0447	1.6292	12.03	11.27
	27.4	2.0	1.0131	13.1	13.6	146.88	0.839	0.0320	1.6292	11.13	10.42
	27.4	4.0	1.0125	12.5	13.0	149.25	0.84	0.0228	1.6292	10.53	9.86
	27.4	8.0	1.0120	12.0	12.5	151.23	0.84	0.0162	1.6292	10.03	9.39
	27.4	15.0	1.0110	11.0	11.5	155.18	0.84	0.0120	1.6292	9.03	8.46
	27.0	30.0	1.0100	10.0	10.5	159.13	0.85	0.0086	1.5260	7.93	7.42
	27.0	60.0	1.0097	9.7	10.2	160.31	0.85	0.0061	1.5260	7.63	7.14
	26.2	120	1.0090	9.0	9.5	163.08	0.86	0.0044	1.3248	6.72	6.30
	27.6	240	1.0085	8.5	9.0	165.05	0.84	0.0031	1.6814	6.58	6.16
	30.8	1440	1.0075	7.5	8.0	169.00	0.78	0.0012	2.5756	6.48	6.06

Table A8 a GRADING FOR JB (B) AFTER 55 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	80.5	5.4	94.6
$^3/_8$ in	9.50	190.1	12.7	82.0
$^1/_4$ in	6.70	194.4	13.0	69.0
$^3/_{16}$ in	4.75	90.0	6.0	63.0
$^1/_8$ in	3.18	130.7	8.7	54.3
No. 7	2.36	95.1	6.3	48.0
No. 14	1.18	6.3	6.1	41.9
No. 25	0.600	5.2	5.0	36.9
No. 36	0.425	2.4	2.3	34.6
No. 52	0.300	2.4	2.3	32.3
NO. 72	0.212	2.3	2.2	30.0
No. 100	0.150	2.1	2.0	28.0
No. 200	0.075	4.5	4.3	23.7
Passing No. 200				
Total		685.6		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	25.0	0.5	1.0175	17.5	18.0	129.50	0.888	0.0618	1.0358	14.94	22.53
	25.0	1.0	1.0170	17.0	17.5	131.48	0.888	0.0441	1.0358	14.44	21.78
	25.0	2.0	1.0165	16.5	17.0	133.45	0.888	0.0314	1.0358	13.94	21.02
	25.0	4.0	1.0164	16.4	16.9	133.85	0.89	0.0222	1.0358	13.84	20.87
	25.0	8.0	1.0160	16.0	16.5	135.43	0.89	0.0158	1.0358	13.44	20.27
	25.0	15.0	1.0157	15.7	16.2	136.61	0.89	0.0116	1.0358	13.14	19.82
	25.0	30.0	1.0152	15.2	15.7	138.59	0.89	0.0083	1.0358	12.64	19.06
	25.0	60.0	1.0146	14.6	15.1	140.96	0.89	0.0059	1.0358	12.04	18.16
	25.0	120	1.0142	14.2	14.7	142.54	0.89	0.0042	1.0358	11.64	17.55
	25.0	240	1.0138	13.8	14.3	144.12	0.89	0.0030	1.0358	11.24	16.95
	25.0	1440	1.0124	12.4	12.9	149.65	0.89	0.0012	1.0358	9.84	14.84

Table A8 b GRADING FOR JB (B) AFTER 25 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	117.1	7.8	92.2
$^3/_8$ in	9.50	150.3	10.0	82.2
$^1/_4$ in	6.70	181.9	12.1	70.0
$^3/_{16}$ in	4.75	99.7	6.6	63.4
$^1/_8$ in	3.18	143.0	9.5	53.9
No. 7	2.36	95.3	6.4	47.5
No. 14	1.18	9.3	8.9	38.7
No. 25	0.600	6.2	5.9	32.8
No. 36	0.425	2.6	2.4	30.3
No. 52	0.300	2.5	2.3	28.0
NO. 72	0.212	2.3	2.2	25.8
No. 100	0.150	1.3	1.2	24.6
No. 200	0.075	5.0	4.7	19.8
Passing No. 200				
Total		692.0		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	25.0	0.5	1.0150	15.0	15.5	139.38	0.888	0.0642	1.0358	12.44	18.56
	25.0	1.0	1.0145	14.5	15.0	141.35	0.888	0.0457	1.0358	11.94	17.82
	25.0	2.0	1.0143	14.3	14.8	142.14	0.888	0.0324	1.0358	11.74	17.52
	25.0	4.0	1.0140	14.0	14.5	143.33	0.89	0.0230	1.0358	11.44	17.07
	25.0	8.0	1.0139	13.9	14.4	143.72	0.89	0.0163	1.0358	11.34	16.92
	25.0	15.0	1.0136	13.6	14.1	144.91	0.89	0.0119	1.0358	11.04	16.47
	25.0	30.0	1.0134	13.4	13.9	145.70	0.89	0.0085	1.0358	10.84	16.18
	25.0	60.0	1.0130	13.0	13.5	147.28	0.89	0.0060	1.0358	10.44	15.58
	25.0	120	1.0124	12.4	12.9	149.65	0.89	0.0043	1.0358	9.84	14.68
	25.0	240	1.0120	12.0	12.5	151.23	0.89	0.0031	1.0358	9.44	14.09
	27.0	1440	1.0100	10.0	10.5	159.13	0.85	0.0012	1.5260	7.93	11.83

Table A8 c GRADING FOR JB (B) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	150.0	10.0	90.0
$^3/_8$ in	9.50	164.7	11.0	79.0
$^1/_4$ in	6.70	205.4	13.7	65.3
$^3/_{16}$ in	4.75	98.9	6.6	58.7
$^1/_8$ in	3.18	129.6	8.6	50.1
No. 7	2.36	100.2	6.7	43.4
No. 14	1.18	12.1	10.5	32.9
No. 25	0.600	6.9	6.0	26.9
No. 36	0.425	2.5	2.2	24.7
No. 52	0.300	2.2	1.9	22.8
NO. 72	0.212	1.9	1.7	21.1
No. 100	0.150	1.5	1.3	19.8
No. 200	0.075	3.8	3.3	16.5
Passing No. 200				
Total		748.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_o=R_h'+M_t-R_o'$	K (%)
11:46	25.0	0.5	1.0140	14.0	14.5	143.33	0.888	0.0651	1.0358	11.44	15.60
	25.0	1.0	1.0135	13.5	14.0	145.30	0.888	0.0463	1.0358	10.94	14.92
	25.0	2.0	1.0133	13.3	13.8	146.09	0.888	0.0328	1.0358	10.74	14.64
	25.0	4.0	1.0131	13.1	13.6	146.88	0.89	0.0233	1.0358	10.54	14.37
	25.0	8.0	1.0130	13.0	13.5	147.28	0.89	0.0165	1.0358	10.44	14.23
	25.0	15.0	1.0124	12.4	12.9	149.65	0.89	0.0121	1.0358	9.84	13.42
	25.0	30.0	1.0124	12.4	12.9	149.65	0.89	0.0086	1.0358	9.84	13.42
	25.0	60.0	1.0120	12.0	12.5	151.23	0.89	0.0061	1.0358	9.44	12.87
	25.0	120	1.0118	11.8	12.3	152.02	0.89	0.0043	1.0358	9.24	12.60
	25.0	240	1.0115	11.5	12.0	153.20	0.89	0.0031	1.0358	8.94	12.19
	25.0	1440	1.0105	10.5	11.0	157.15	0.89	0.0013	1.0358	7.94	10.82

Table A8 d GRADING FOR JB (B) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	190.9	12.7	87.3
$^3/_8$ in	9.50	220.6	14.7	72.6
$^1/_4$ in	6.70	252.0	16.8	55.8
$^3/_{16}$ in	4.75	122.6	8.2	47.6
$^1/_8$ in	3.18	163.0	10.9	36.7
No. 7	2.36	133.5	8.9	27.8
No. 14	1.18	6.5	3.6	24.2
No. 25	0.600	4.3	2.4	21.8
No. 36	0.425	2.1	1.2	20.6
No. 52	0.300	2.2	1.2	19.4
NO. 72	0.212	2.2	1.2	18.2
No. 100	0.150	1.8	1.0	17.2
No. 200	0.075	3.5	1.9	15.2
Passing No. 200				
Total		949.1		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_o=R_h'+M_t-R_o'$	K (%)
10:00am	25.0	0.5	1.0190	19.0	19.5	123.58	0.888	0.0604	1.0358	16.44	14.36
	25.0	1.0	1.0180	18.0	18.5	127.53	0.888	0.0434	1.0358	15.44	13.49
	25.0	2.0	1.0176	17.6	18.1	129.11	0.888	0.0309	1.0358	15.04	13.14
	25.0	4.0	1.0174	17.4	17.9	129.90	0.89	0.0219	1.0358	14.84	12.96
	25.0	8.0	1.0170	17.0	17.5	131.48	0.89	0.0156	1.0358	14.44	12.61
	25.0	15.0	1.0168	16.8	17.3	132.27	0.89	0.0114	1.0358	14.24	12.44
	25.0	30.0	1.0160	16.0	16.5	135.43	0.89	0.0082	1.0358	13.44	11.74
	25.0	60.0	1.0157	15.7	16.2	136.61	0.89	0.0058	1.0358	13.14	11.48
	25.0	120	1.0154	15.4	15.9	137.80	0.89	0.0041	1.0358	12.84	11.21
	25.0	240	1.0150	15.0	15.5	139.38	0.89	0.0029	1.0358	12.44	10.87
	25.0	1440	1.0144	14.4	14.9	141.75	0.89	0.0012	1.0358	11.84	10.34

Table A9 a GRADING FOR AJ-AD (B) AFTER 55 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
2½ in	63.00			
2 in	53.00			
1½ in	37.10			
1 in	26.50			
¾ in	19.00			100.0
½ in	13.20	48.0	3.2	96.8
⅜ in	9.50	70.8	4.7	92.1
¼ in	6.70	95.7	6.4	85.7
5/32 in	4.75	93.7	6.2	79.5
⅛ in	3.18	116.6	7.8	71.7

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	82.6	5.5	66.2
No. 14	1.18	13.2	17.5	48.7
No. 25	0.600	10.3	13.9	34.8
No. 36	0.425	3.8	5.0	29.8
No. 52	0.300	3.2	4.3	25.5
NO. 72	0.212	2.6	3.5	22.0
No. 100	0.150	1.8	2.4	19.6
No. 200	0.075	4.0	5.3	14.4
Passing No. 200				
Total		424.7		

Hydrometer test for materisl passing 2.36mm BS Test Selve. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, Rif	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M	$R_o=R_h'+M_t-R_o'$	K (%)
9:18	27.4	0.5	1.0085	8.5	9.0	165.05	0.839	0.0679	1.6292	6.53	13.98
	27.4	1.0	1.0080	8.0	8.5	167.03	0.839	0.0483	1.6292	6.03	12.54
	27.4	2.0	1.0076	7.6	8.1	168.61	0.839	0.0343	1.6292	5.63	11.71
	27.4	4.0	1.0072	7.2	7.7	170.19	0.84	0.0244	1.6292	5.23	10.88
	27.4	8.0	1.0070	7.0	7.5	170.98	0.84	0.0173	1.6292	5.03	10.46
	27.4	15.0	1.0067	6.7	7.2	172.16	0.84	0.0127	1.6292	4.73	9.84
	27.0	30.0	1.0064	6.4	6.9	173.35	0.85	0.0090	1.5260	4.33	9.00
	27.0	60.0	1.0061	6.1	6.6	174.53	0.85	0.0064	1.5260	4.03	8.38
	26.2	120	1.0059	5.9	6.4	175.32	0.86	0.0046	1.3248	3.62	7.54
	27.6	240	1.0055	5.5	6.0	176.90	0.84	0.0032	1.6814	3.58	7.45
	30.8	1440	1.0045	4.5	5.0	180.85	0.78	0.0013	2.5756	3.48	7.23

Table A9 b GRADING FOR AJ-AD (B) AFTER 25 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
2½ in	63.00			
2 in	53.00			
1½ in	37.10			
1 in	26.50			
¾ in	19.00			100.0
½ in	13.20	64.6	4.3	95.7
⅜ in	9.50	53.1	3.5	92.2
¼ in	6.70	109.2	7.3	84.9
5/32 in	4.75	96.9	6.5	78.4
⅛ in	3.18	135.0	9.0	69.4

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	80.8	5.4	64.0
No. 14	1.18	15.1	19.3	44.7
No. 25	0.600	10.9	13.9	30.8
No. 36	0.425	3.7	4.7	26.1
No. 52	0.300	3.0	3.8	22.3
NO. 72	0.212	2.3	3.0	19.3
No. 100	0.150	1.9	2.4	16.9
No. 200	0.075	4.0	5.1	11.8
Passing No. 200				
Total		458.7		

Hydrometer test for materisl passing 2.36mm BS Test Selve. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, Rif	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M	$R_o=R_h'+M_t-R_o'$	K (%)
9:07	27.4	0.5	1.0075	7.5	8.0	169.00	0.839	0.0687	1.6292	5.53	11.12
	27.4	1.0	1.0069	6.9	7.4	171.37	0.839	0.0489	1.6292	4.93	9.91
	27.4	2.0	1.0066	6.6	7.1	172.56	0.839	0.0347	1.6292	4.63	9.31
	27.4	4.0	1.0064	6.4	6.9	173.35	0.84	0.0246	1.6292	4.43	8.91
	27.4	8.0	1.0060	6.0	6.5	174.93	0.84	0.0175	1.6292	4.03	8.10
	27.4	15.0	1.0059	5.9	6.4	175.32	0.84	0.0128	1.6292	3.93	7.90
	27.0	30.0	1.0058	5.8	6.3	175.72	0.85	0.0091	1.5260	3.73	7.49
	27.0	60.0	1.0055	5.5	6.0	176.90	0.85	0.0064	1.5260	3.43	6.89
	26.2	120	1.0054	5.4	5.9	177.30	0.86	0.0046	1.3248	3.12	6.29
	27.6	240	1.0050	5.0	5.5	178.88	0.84	0.0032	1.6814	3.08	6.20
	30.8	1440	1.0039	3.9	4.4	183.22	0.78	0.0013	2.5756	2.88	5.78

Table A9 c GRADING FOR AJ-AD (B) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	30.6	3.1	96.9
$^3/_8$ in	9.50	50.3	5.0	91.9
$^1/_4$ in	6.70	91.5	9.2	82.8
$^3/_{16}$ in	4.75	83.8	8.4	74.4
$^1/_8$ in	3.18	134.2	13.4	61.0

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	92.9	9.3	51.7
No. 14	1.18	12.9	13.3	38.4
No. 25	0.600	11.7	12.1	26.3
No. 36	0.425	3.9	4.1	22.2
No. 52	0.300	3.2	3.3	18.9
NO. 72	0.212	2.5	2.6	16.3
No. 100	0.150	2.5	2.6	13.8
No. 200	0.075	3.8	3.9	9.8
Passing No. 200				
Total		390.3		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
9:57	27.4	0.5	1.0078	7.8	8.3	167.82	0.839	0.0684	1.6292	5.83	9.47
	27.4	1.0	1.0070	7.0	7.5	170.98	0.839	0.0489	1.6292	5.03	8.17
	27.4	2.0	1.0068	6.8	7.3	171.77	0.839	0.0346	1.6292	4.83	7.85
	27.4	4.0	1.0066	6.6	7.1	172.56	0.84	0.0245	1.6292	4.63	7.52
	27.4	8.0	1.0064	6.4	6.9	173.35	0.84	0.0174	1.6292	4.43	7.20
	27.4	15.0	1.0062	6.2	6.7	174.14	0.84	0.0127	1.6292	4.23	6.87
	27.0	30.0	1.0060	6.0	6.5	174.93	0.85	0.0091	1.5260	3.93	6.38
	27.0	60.0	1.0058	5.8	6.3	175.72	0.85	0.0064	1.5260	3.73	6.05
	26.2	120	1.0056	5.6	6.1	176.51	0.86	0.0046	1.3248	3.32	5.40
	27.6	240	1.0052	5.2	5.7	178.09	0.84	0.0032	1.6814	3.28	5.33
	30.8	1440	1.0040	4.0	4.5	182.83	0.78	0.0013	2.5756	2.98	4.84

Table A9 d GRADING FOR AJ-AD (B) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	106.4	7.1	92.9
$^3/_8$ in	9.50	129.7	8.6	84.3
$^1/_4$ in	6.70	212.5	14.2	70.1
$^3/_{16}$ in	4.75	187.6	12.5	57.6
$^1/_8$ in	3.18	245.4	16.4	41.2

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	157.1	10.5	30.8
No. 14	1.18	14.1	8.7	22.1
No. 25	0.600	11.4	7.0	,15.1
No. 36	0.425	3.8	2.3	12.7
No. 52	0.300	3.2	1.9	10.8
NO. 72	0.212	2.4	1.5	9.3
No. 100	0.150	1.6	1.0	8.3
No. 200	0.075	1.2	0.7	7.6
Passing No. 200				
Total		881.6		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
10:03	27.4	0.5	1.0095	9.5	10.0	161.10	0.839	0.0671	1.6292	7.53	7.29
	27.4	1.0	1.0090	9.0	9.5	163.08	0.839	0.0477	1.6292	7.03	6.80
	27.4	2.0	1.0086	8.6	9.1	164.66	0.839	0.0339	1.6292	6.63	6.42
	27.4	4.0	1.0083	8.3	8.8	165.84	0.84	0.0241	1.6292	6.33	6.13
	27.4	8.0	1.0080	8.0	8.5	167.03	0.84	0.0171	1.6292	6.03	5.84
	27.4	15.0	1.0078	7.8	8.3	167.82	0.84	0.0125	1.6292	5.83	5.64
	27.0	30.0	1.0074	7.4	7.9	169.40	0.85	0.0089	1.5260	5.33	5.16
	27.0	60.0	1.0068	6.8	7.3	171.77	0.85	0.0064	1.5260	4.73	4.57
	26.2	120	1.0066	6.6	7.1	172.56	0.86	0.0045	1.3248	4.32	4.19
	27.6	240	1.0062	6.2	6.7	174.14	0.84	0.0032	1.6814	4.28	4.14
	30.8	1440	1.0051	5.1	5.6	178.48	0.78	0.0013	2.5756	4.08	3.95

Table A10 a GRADING FOR K-W (SB) AFTER 55 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	100.1	6.7	93.3
$^3/_8$ in	9.50	103.7	6.9	86.4
$^1/_4$ in	6.70	130.9	8.7	77.7
$^3/_{16}$ in	4.75	83.2	5.5	72.1
$^1/_8$ in	3.18	96.5	6.4	65.7
No. 7	2.36	61.1	4.1	61.6
No. 14	1.18	4.2	5.2	56.5
No. 25	0.600	3.6	4.4	52.1
No. 36	0.425	1.7	2.1	49.9
No. 52	0.300	2.5	3.0	46.9
NO. 72	0.212	2.8	3.5	43.4
No. 100	0.150	2.5	3.1	40.3
No. 200	0.075	6.5	8.0	32.3
Passing No. 200				
Total		514.4		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_c=R_h'+M_t-R_o'$	K (%)
11:06	27.4	0.5	1.0175	17.5	18.0	129.50	0.839	0.0601	1.6292	15.53	30.06
	27.4	1.0	1.0155	15.5	16.0	137.40	0.839	0.0438	1.6292	13.53	26.19
	27.4	2.0	1.0144	14.4	14.9	141.75	0.839	0.0315	1.6292	12.43	24.06
	27.4	4.0	1.0136	13.6	14.1	144.91	0.84	0.0225	1.6292	11.63	22.51
	27.4	8.0	1.0130	13.0	13.5	147.28	0.84	0.0160	1.6292	11.03	21.35
	27.4	15.0	1.0125	12.5	13.0	149.25	0.84	0.0118	1.6292	10.53	20.38
	27.0	30.0	1.0120	12.0	12.5	151.23	0.85	0.0084	1.5260	9.93	19.22
	27.0	60.0	1.0114	11.4	11.9	153.60	0.85	0.0060	1.5260	9.33	18.06
	26.2	120	1.0110	11.0	11.5	155.18	0.86	0.0043	1.3248	8.72	16.89
	27.6	240	1.0106	10.6	11.1	156.76	0.84	0.0030	1.6814	8.68	16.81
	30.8	1440	1.0086	8.6	9.1	164.66	0.78	0.0012	2.5756	7.58	14.67

Table A10 b GRADING FOR K-W (SB) AFTER 25 BLOWS.

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 549g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	56.2	10.2	89.8
$^3/_8$ in	9.50	32.9	6.0	83.8
$^1/_4$ in	6.70	53.8	9.8	74.0
$^3/_{16}$ in	4.75	31.7	5.8	68.2
$^1/_8$ in	3.18	37.9	6.9	61.3
No. 7	2.36	30.4	5.5	55.8
No. 14	1.18	4.6	5.1	50.7
No. 25	0.600	3.5	3.9	46.8
No. 36	0.425	1.6	1.8	45.0
No. 52	0.300	2.4	2.6	42.3
NO. 72	0.212	2.8	3.1	39.3
No. 100	0.150	2.5	2.8	36.4
No. 200	0.075	6.1	6.8	29.6
Passing No. 200				
Total		212.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_c=R_h'+M_t-R_o'$	K (%)
10:45	27.4	0.5	1.0170	17.0	17.5	131.48	0.839	0.0606	1.6292	15.03	26.36
	27.4	1.0	1.0155	15.5	16.0	137.40	0.839	0.0438	1.6292	13.53	23.73
	27.4	2.0	1.0140	14.0	14.5	143.33	0.839	0.0316	1.6292	12.03	21.10
	27.4	4.0	1.0135	13.5	14.0	145.30	0.84	0.0225	1.6292	11.53	20.22
	27.4	8.0	1.0129	12.9	13.4	147.67	0.84	0.0161	1.6292	10.93	19.17
	27.4	15.0	1.0120	12.0	12.5	151.23	0.84	0.0119	1.6292	10.03	17.59
	27.0	30.0	1.0116	11.6	12.1	152.81	0.85	0.0085	1.5260	9.53	16.71
	27.0	60.0	1.0113	11.3	11.8	153.99	0.85	0.0060	1.5260	9.23	16.18
	26.2	120	1.0108	10.8	11.3	155.97	0.86	0.0043	1.3248	8.52	14.95
	27.6	240	1.0103	10.3	10.8	157.94	0.84	0.0030	1.6814	8.38	14.70
	30.8	1440	1.0085	8.5	9.0	165.05	0.78	0.0012	2.5756	7.48	13.11

Table A10 c GRADING FOR K-W (SB) AFTER 10 BLOWS.

Wet Seiving over 2.36mm BS Test Seive.

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	169.8	11.3	88.7
$^3/_8$ in	9.50	149.0	9.9	78.7
$^1/_4$ in	6.70	144.1	9.6	69.1
$^3/_{16}$ in	4.75	91.9	6.1	63.0
$^1/_8$ in	3.18	94.5	6.3	56.7

Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	52.2	3.5	53.2
No. 14	1.18	4.9	5.2	48.1
No. 25	0.600	3.6	3.8	44.3
No. 36	0.425	1.7	1.8	42.4
No. 52	0.300	2.4	2.6	39.9
NO. 72	0.212	2.7	2.9	37.0
No. 100	0.150	2.3	2.4	34.6
No. 200	0.075	5.7	6.1	28.5
Passing No. 200				
Total		649.2		

Hydrometer test for material passing 2.36mm BS Test Seive.

Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_c=R_h'+M_t-R_o'$	K (%)
11:46	27.4	0.5	1.0170	17.0	17.5	131.48	0.839	0.0606	1.6292	15.03	25.13
	27.4	1.0	1.0155	15.5	16.0	137.40	0.839	0.0438	1.6292	13.53	22.62
	27.4	2.0	1.0150	15.0	15.5	139.38	0.839	0.0312	1.6292	13.03	21.78
	27.4	4.0	1.0140	14.0	14.5	143.33	0.84	0.0224	1.6292	12.03	20.11
	27.4	8.0	1.0130	13.0	13.5	147.28	0.84	0.0160	1.6292	11.03	18.44
	27.4	15.0	1.0125	12.5	13.0	149.25	0.84	0.0118	1.6292	10.53	17.60
	27.0	30.0	1.0120	12.0	12.5	151.23	0.85	0.0084	1.5260	9.93	16.60
	27.0	60.0	1.0116	11.6	12.1	152.81	0.85	0.0060	1.5260	9.53	15.93
	26.2	120	1.0110	11.0	11.5	155.18	0.86	0.0043	1.3248	8.72	14.59
	27.6	240	1.0105	10.5	11.0	157.15	0.84	0.0030	1.6814	8.58	14.35
	30.8	1440	1.0095	9.5	10.0	161.10	0.78	0.0012	2.5756	8.48	14.17

Table A10 d GRADING FOR K-W (SB) AFTER 0 BLOWS.

Wet Seiving over 2.36mm BS Test Seive.

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			
$^3/_4$ in	19.00			100.0
$^1/_2$ in	13.20	322.9	21.5	78.5
$^3/_8$ in	9.50	134.9	9.0	69.5
$^1/_4$ in	6.70	134.6	9.0	60.5
$^3/_{16}$ in	4.75	97.4	6.5	54.0
$^1/_8$ in	3.18	118.4	7.9	46.1

Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing
BS designation	Metric (mm)			
No. 7	2.36	72.9	4.9	41.3
No. 14	1.18	2.3	1.9	39.3
No. 25	0.600	2.9	2.4	36.9
No. 36	0.425	1.7	1.4	35.5
No. 52	0.300	2.6	2.1	33.3
NO. 72	0.212	3.1	2.5	30.8
No. 100	0.150	2.7	2.2	28.6
No. 200	0.075	6.4	5.3	23.3
Passing No. 200				
Total		808.2		

Hydrometer test for material passing 2.36mm BS Test Seive.

Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_c=R_h'+M_t-R_o'$	K (%)
11:46	27.4	0.5	1.0180	18.0	18.5	127.53	0.839	0.0597	1.6292	16.03	20.81
	27.4	1.0	1.0160	16.0	16.5	135.43	0.839	0.0435	1.6292	14.03	18.21
	27.4	2.0	1.0146	14.6	15.1	140.96	0.839	0.0314	1.6292	12.63	16.39
	27.4	4.0	1.0139	13.9	14.4	143.72	0.84	0.0224	1.6292	11.93	15.48
	27.4	8.0	1.0135	13.5	14.0	145.30	0.84	0.0159	1.6292	11.53	14.96
	27.4	15.0	1.0130	13.0	13.5	147.28	0.84	0.0117	1.6292	11.03	14.32
	27.0	30.0	1.0125	12.5	13.0	149.25	0.85	0.0084	1.5260	10.43	13.53
	27.0	60.0	1.0120	12.0	12.5	151.23	0.85	0.0060	1.5260	9.93	12.88
	26.2	120	1.0117	11.7	12.2	152.41	0.86	0.0043	1.3248	9.42	12.23
	27.6	240	1.0110	11.0	11.5	155.18	0.84	0.0030	1.6814	9.08	11.79
	30.8	1440	1.0104	10.4	10.9	157.55	0.78	0.0012	2.5756	9.38	12.17

...e A12 COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.

...RCE OF MATERIAL: T-K (SB)

...ple preparation	1	2	3	4
...s of cylinder + Wet sample (gm)	11978	12418	12627	12576
...s of cylinder (gm)	7303	7303	7303	7303
...s of wet sample (gm)	4675	5115	5324	5272
...k density (Mg/m^3)	2.24	2.45	2.55	2.52

...er Content Determination

...No.	1		2		3		4	
...ainer No.	K2	A39	A42	B3	B1	A3	A22	A18
...s of container+Wet soil (gm)	70.62	94.88	71.00	81.43	81.08	72.87	86.77	79.79
...s of container+Dry soil (gm)	69.04	92.5	67.3	77.32	75.42	68.04	78.73	73.43
...s of container (gm)	14.79	14.28	14.67	15.30	14.58	15.44	14.75	14.39
...s of water (gm)	1.58	2.38	3.70	4.11	5.66	4.83	7.04	6.36
...s of dry soil (gm)	54.25	78.22	52.63	62.02	60.84	52.60	63.98	59.04
...r content (%)	2.91	3.04	7.03	6.63	9.30	9.18	11.00	10.77
...age water content	2.98		6.83		9.24		10.89	
...ensity (Mg/m^3)	2.173		2.291		2.332		2.275	

...ld characteristics

...ht of Mould (cm)	11.5
...meter of mould (cm)	15.21
...me of Mould (cc)	2090

...le A11 COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.

...URCE OF MATERIAL: T-K (B)

...ple preparation	1	2	3	4	5
...s of cylinder + Wet sample (gm)	11992	12239	12759	12499	12184
...s of cylinder (gm)	7516	7516	7516	7516	7394
...s of wet sample (gm)	4476	4723	5243	4983	4790
...k density (Mg/m^3)	2.142	2.260	2.509	2.385	2.292

...ter Content Determination

...No.	1		2		3		4	
...tainer No.	A5	E6	A	A16	B6	100	E2	A23
...s of container+Wet soil (gm)	76.31	79.88	72.11	74.23	68.41	71.31	77.17	74.57
...s of container+Dry soil (gm)	74.76	78.3	69.13	71.06	64.13	66.63	70.59	68.25
...s of container (gm)	14.20	14.44	14.83	14.22	14.28	14.36	14.76	15.32
...s of water (gm)	1.55	1.58	2.98	3.17	4.28	4.68	6.58	6.32
...s of dry soil (gm)	60.56	63.86	54.30	56.84	49.85	52.27	55.83	52.93
...ter content (%)	2.56	2.47	5.49	5.58	8.59	8.95	11.79	11.94
...rage water content	2.52		5.53		8.77		11.86	
...y density (Mg/m^3)	2.090		2.142		2.307		2.132	

...uld characteristics

...ght of Mould (cm)	11.5
...meter of mould (cm)	15.21
...ume of Mould (cc)	2090

e A15 COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.

RCE OF MATERIAL: K-A (SB)

ple preparation	1	2	3	4
s of cylinder + Wet sample (gm)	12319	12763	12697	12619
s of cylinder (gm)	7513	7513	7513	7513
s of wet sample (gm)	4806	5250	5184	5106
density (Mg/m^3)	2.30	2.51	2.48	2.44

er Content Determination

No.	1		2		3		4	
tainer No.	X3	X10	C3	D9	D10	C11	112	C4
s of container+Wet soil (gm)	96.80	97.14	82.10	73.12	76.92	78.65	84.45	85.59
s of container+Dry soil (gm)	93.53	93.94	77.98	69.01	71.66	72.93	76.54	78.67
s of container (gm)	17.85	17.62	18.70	18.08	18.11	18.12	17.88	18.24
s of water (gm)	3.27	3.20	4.12	4.11	5.26	5.72	7.91	6.92
s of dry soil (gm)	75.68	76.32	59.28	50.93	53.55	54.81	58.66	60.43
er content (%)	4.32	4.19	6.95	8.07	9.82	10.44	13.48	11.45
rage water content	4.26		7.51		10.13		12.47	
density (Mg/m^3)	2.21		2.34		2.25		2.17	

ld characteristics

ght of Mould (cm)	11.5
meter of mould (cm)	15.21
ume of Mould (cc)	2090

le 13A COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.

URCE OF MATERIAL: JZ-Y (SB)

mple preparation	1	2	3	4	5
ss of cylinder + Wet sample (gm)	12014	12514	12708	12553	12451
ss of cylinder (gm)	7513	7513	7513	7513	7513
ss of wet sample (gm)	4501	5001	5195	5040	4938
k density (Mg/m^3)	2.15	2.39	2.49	2.41	2.36

ter Content Determination

st No.	1		2		3		4		5	
ntainer No.	X8	D4	XX3	D13	X5	X13	C18	D5	D11	C14
ss of container+Wet soil (gm)	99.89	96.42	92.80	85.33	94.72	96.24	99.90	96.62	89.79	97.65
ss of container+Dry soil (gm)	96.49	93.16	87.58	80.58	87.95	88.9	90.98	88.33	80.65	87.4
ss of container (gm)	17.78	18.21	17.75	18.28	18.26	17.73	17.66	17.95	17.88	17.95
ss of water (gm)	3.40	3.26	5.22	4.75	6.77	7.34	8.92	8.29	9.14	10.25
ss of dry soil (gm)	78.71	74.95	69.83	62.30	69.69	71.17	73.32	70.38	62.77	69.45
ater content (%)	4.32	4.35	7.48	7.62	9.71	10.31	12.17	11.78	14.56	14.76
erage water content	4.33		7.55		10.01		11.97		14.66	
y density (Mg/m^3)	2.06		2.23		2.26		2.15		2.06	

ould characteristics

eight of Mould (cm)	11.5
iameter of mould (cm)	15.21
olume of Mould (cc)	2090

e A14 COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.

RCE OF MATERIAL: L-BP (SB)

ple preparation	1	2	3	4	5
s of cylinder + Wet sample (gm)	11897	12330	12503	12352	12298
s of cylinder (gm)	7553	7553	7553	7553	7553
s of wet sample (gm)	4344	4777	4950	4799	4745
density (Mg/m^3)	2.079	2.286	2.369	2.297	2.271

er Content Determination

No.	1		2		3		4		5	
tainer No.	D9	C9	C6	C17	D8	D5	D14	X9	X14	D4
s of container+Wet soil (gm)	128.11	123.79	110.64	119.02	93.77	93.98	115.38	108.86	111.70	114.47
s of container+Dry soil (gm)	124.03	119.27	105.21	112.24	86.21	86.50	104.55	98.31	98.12	99.65
s of container (gm)	18.12	17.88	17.77	17.81	18.00	17.97	18.25	17.93	17.80	18.21
s of water (gm)	4.08	4.52	5.43	6.78	7.56	7.48	10.83	10.55	13.58	14.82
s of dry soil (gm)	105.91	101.39	87.44	94.43	68.21	68.53	86.30	80.38	80.32	81.44
er content (%)	3.85	4.46	6.21	7.18	11.08	10.91	12.55	13.13	16.91	18.20
rage water content	4.16		6.69		11.00		12.84		17.55	
density (Mg/m^3)	1.996		2.143		2.134		2.035		1.942	

uld characteristics

ght of Mould (cm)	11.5
meter of mould (cm)	15.21
ume of Mould (cc)	2090

ple A16 COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.

URCE OF MATERIAL -GR (B)

mple preparation	1	2	3	4	5
ss of cylinder + Wet sample (gm)	11897	12330	12503	12352	12298
ss of cylinder (gm)	7553	7553	7553	7553	7553
ss of wet sample (gm)	4344	4777	4950	4799	4745
lk density (Mg/m^3)	2.079	2.286	2.369	2.297	2.271

ter Content Determination

st No.	1		2		3		4		5	
ntainer No.	A15	B5	E6	A34	A40	E2	A6	A41	A27	A16
ass of container+Wet soil (gm)	82.67	72.50	85.03	87.45	85.40	90.14	92.08	83.55	105.66	114.59
ass of container+Dry soil (gm)	79.70	70.05	80.75	82.92	80.20	84.58	85.41	76.16	95.92	103.19
ass of container (gm)	15.35	14.24	14.44	14.10	14.73	14.77	14.19	14.23	12.90	14.23
ass of water (gm)	2.97	2.45	4.28	4.53	5.20	5.56	6.67	7.39	9.74	11.40
ass of dry soil (gm)	64.35	55.81	66.31	68.82	65.47	69.81	71.22	61.93	83.02	88.96
ater content (%)	4.62	4.39	6.45	6.58	7.94	7.96	9.37	11.93	11.73	12.81
verage water content	4.50		6.52		7.95		10.65		12.27	
ry density (Mg/m^3)	1.989		2.146		2.194		2.076		2.032	

ould characteristics

eight of Mould (cm)	11.5
iameter of mould (cm)	15.21
olume of Mould (cc)	2090

ble A17 COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.

OURCE OF MATERIAL: A-N (SB)

mple preparation	1	2	3	4	5
ass of cylinder + Wet sample (gm)	11701	11888	12315	12343	12184
ass of cylinder (gm)	7394	7394	7394	7394	7394
ass of wet sample (gm)	4307	4494	4921	4949	4790
ulk density (Mg/m^3)	2.061	2.151	2.355	2.368	2.292

ater Content Determination

st No.	1		2		3		4		5	
ontainer No.	A42	A50	A6	A30	A40	A12	E5	A33	B2	A26
lass of container+Wet soil (gm)	89.49	97.47	70.05	73.35	76.70	78.57	77.79	79.89	78.25	73.07
lass of container+Dry soil (gm)	89.10	97.10	67.84	71.26	73.35	75.23	72.70	74.84	72.21	67.82
lass of container (gm)	14.68	14.32	14.19	15.02	14.73	14.25	15.19	14.53	14.93	13.21
lass of water (gm)	0.39	0.37	2.21	2.09	3.35	3.34	5.09	5.05	6.04	5.25
lass of dry soil (gm)	74.42	82.78	53.65	56.24	58.62	60.98	57.51	60.31	57.28	54.61
ater content (%)	0.52	0.45	4.12	3.72	5.71	5.48	8.85	8.37	10.54	9.61
verage water content	0.49		3.92		5.60		8.61		10.08	
ry density (Mg/m^3)	2.051		2.070		2.230		2.181		2.074	

ould characteristics

eight of Mould (cm)	11.5
iameter of mould (cm)	15.21
olume of Mould (cc)	2090

able A18 COMPACTION TEST RESULTS- MODIFIED AASHTO

OURCE OF MATERIAL : JB (B)

ample preparation	1	2	3	4	5
lass of cylinder + Wet sample (gm)	11509	11667	12087	12283	12133
lass of cylinder (gm)	7394	7394	7394	7394	7394
lass of wet sample (gm)	4115	4273	4693	4889	4739
ulk density (Mg/m^3)	1.969	2.045	2.246	2.340	2.268

ater Content Determination

est No.	1		2		3		4		5	
ontainer No.	D6	X2	X4	D12	112	D1	D14	C67	XX3	XY1
lass of container+Wet soil (gm)	99.99	74.93	101.27	88.14	95.83	97.73	102.84	92.96	80.90	89.64
lass of container+Dry soil (gm)	99.25	74.40	98.29	85.58	91.67	93.43	96.66	87.70	74.81	82.73
lass of container (gm)	18.64	18.04	18.15	18.04	17.89	18.02	18.25	18.14	17.78	18.50
lass of water (gm)	0.74	0.53	2.98	2.56	4.16	4.30	6.18	5.26	6.09	6.91
lass of dry soil (gm)	80.61	56.36	80.14	67.54	73.78	75.41	78.41	69.56	57.03	64.23
ater content (%)	0.92	0.94	3.72	3.79	5.64	5.70	7.88	7.56	10.68	10.76
verage water content	0.93		3.75		5.67		7.72		10.72	
ry density (Mg/m^3)	1.951		1.971		2.125		2.172		2.049	

ould characteristics

eight of Mould (cm)	11.5
iameter of mould (cm)	15.21
olume of Mould (cc)	2090

ble A19 **COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.**

URCE OF MATERIAL: AJ-AD (B)

mple preparation	1	2	3	4	5
ss of cylinder + Wet sample (gm)	11689	12134	12354	12232	12202
ss of cylinder (gm)	7428	7428	7428	7428	7428
ss of wet sample (gm)	4261	4706	4926	4804	4774
k density (Mg/m^3)	2.039	2.252	2.357	2.299	2.285

ter Content Determination

x No.	1		2		3		4		5	
ntainer No.	C8	D10	D7	X10	X11	D6	X14	X03	X3	C16
ss of container+Wet soil (gm)	87.00	82.68	73.35	81.69	83.47	81.94	88.93	83.93	86.86	86.41
ss of container+Dry soil (gm)	85.64	81.45	70.87	78.6	79.02	77.17	81.76	77.34	77.88	77.83
ss of container (gm)	18.03	18.11	17.85	17.68	17.80	18.64	17.82	17.74	17.85	17.83
ss of water (gm)	1.36	1.23	2.48	3.09	4.45	4.77	7.18	6.59	8.98	8.48
ss of dry soil (gm)	67.61	63.34	53.02	60.92	61.22	58.53	63.93	59.60	60.03	60.00
ter content (%)	2.01	1.94	4.68	5.07	7.27	8.15	11.23	11.06	14.96	14.13
erage water content	1.98		4.87		7.71		11.14		14.55	
k density (Mg/m^3)	2.000		2.148		2.189		2.069		1.987	

ould characteristics

ght of Mould (cm)	11.5
meter of mould (cm)	15.21
ume of Mould (cc)	2090

ble A20 **COMPACTION (MODIFIED AASHTO T190) TEST RESULTS.**

OURCE OF MATERIAL: K-W (SB)

mple preparation	1	2	3	4	5	6
ss of cylinder + Wet sample (gm)	11473	11674	12072	12311	12163	12151
ss of cylinder (gm)	7353	7353	7353	7353	7353	7353
ss of wet sample (gm)	4120	4321	4719	4958	4810	4798
k density (Mg/m^3)	1.972	2.068	2.258	2.373	2.302	2.296

ter Content Determination

x No.	1		2		3		4		5		5	
ntainer No.	E6	A18	B3	A28	A31	B6	A2	B5	A26	A	X3	X10
ss of container+Wet soil (gm)	75.67	70.11	82.76	81.18	68.21	66.48	68.01	67.32	78.75	81.90	82.64	83.13
ss of container+Dry soil (gm)	74.36	68.82	79.26	77.82	63.96	62.26	62.55	61.73	70.24	73.45	72.12	73.52
ss of container (gm)	14.44	14.39	15.27	14.25	14.36	14.28	14.38	14.21	13.20	14.75	13.45	14.75
ss of water (gm)	1.31	1.29	3.50	3.36	4.25	4.22	5.46	5.59	8.51	8.45	10.52	9.61
ss of dry soil (gm)	59.92	54.43	63.99	63.57	49.60	47.98	48.17	47.52	57.04	58.70	58.67	58.77
ter content (%)	2.19	2.37	5.47	5.29	8.57	8.80	11.33	11.76	14.92	14.40	17.93	16.35
erage water content	2.28		5.38		8.68		11.55		14.66		17.14	
k density (Mg/m^3)	1.928		1.962		2.078		2.127		2.003		1.947	

ould characteristics

ght of Mould (cm)	11.5
meter of mould (cm)	15.21
ume of Mould (cc)	2090

Table A21 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM T-K (B)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A2		B2		A6	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,659		12,692		12340	
Mass of Mould	7,375		7,498		7,417	
Mass of wet sample	5,284		5,194		4,923	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.498		2.456		2.328	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A	K4	K2	A22	E6	A16
Wet sample + container (g)	92.57	85.83	80.82	86.15	75.41	69.29
Dry sample + container (g)	86.28	80.15	75.48	80.38	70.49	64.68
Mass of container	14.81	15.59	14.79	14.74	14.42	12.20
Mass of water	6.29	5.68	5.34	5.77	4.92	4.61
Mass of dry sample	71.47	64.56	60.69	65.64	56.07	52.48
Water content	8.80	8.80	8.80	8.79	8.77	8.78
Average Water content	8.80		8.79		8.78	
Dry density	**2.30**		**2.26**		**2.14**	
MDD	**2.307**					
Relative Compaction (%)	**100**		**98**		**93**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12722		12768		12478	
Mass of mould	7,375		7,498		7,417	
Mass of wet sample	5,347		5,270		5,061	
Bulk density (g/cc)	2.53		2.49		2.39	
AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	E5	K4	A3	E2	A5	K1
Wet sample + container (g)	64.28	77.64	77.67	74.4	77.61	83.49
Dry sample + container (g)	59.79	71.96	71.88	68.86	71.68	77.20
Mass of container	15.19	15.61	15.44	14.76	14.20	16.28
Mass of water	4.49	5.68	5.79	5.54	5.93	6.29
Mass of dry sample	44.60	56.35	56.44	54.10	57.48	60.92
Water content	10.07	10.08	10.26	10.24	10.32	10.33
Average Water content	10.07		10.25		10.32	
Dry density	**2.30**		**2.26**		**2.17**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	17	0.442		18	0.468		22	0.572	
0.50	39	1.014		39	1.014		41	1.066	
0.75	69	1.794		68	1.768		60	1.56	
1.00	104	2.704		104	2.704		75	1.95	
1.25	140	3.64	73	146	3.796	90	88	2.288	30
1.50	172	4.472		188	4.888		103	2.678	
1.75	206	5.356		235	6.11		115	2.99	
2.00	244	6.344		282	7.332		128	3.328	
2.25	284	7.384		327	8.502		141	3.666	
2.50	323	8.398		370	9.62		153	3.978	
2.75	360	9.36		411	10.686		166	4.316	
3.00	395	10.27		453	11.778		175	4.55	
3.50	466	12.116		530	13.78		199	5.174	
4.00	536	13.936		603	15.678		219	5.694	
4.50	605	15.73		668	17.368		241	6.266	
5.00	678	17.628	**94**	731	19.006	**103**	262	6.812	**34**
5.50	745	19.37		790	20.54		283	7.358	
6.00	811	21.086		847	22.022		303	7.878	
6.50	888	23.088		900	23.4		322	8.372	
7.00	948	24.648		952	24.752		341	8.866	
7.50									
8.00									

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	7/6/2001	3:00 PM	0	7/6/2001	3:00 PM	0	7/6/2001	3:00 PM	0
	8/6/2001	"	1	8/6/2001	"	2	8/6/2001	"	7
	9/6/2001	"	2	9/6/2001	"	3	9/6/2001	"	8
	10/6/2001	"	2	10/6/2001	"	4	10/6/2001	"	10
	11/6/2001	"	2	11/6/2001	"	5	11/6/2001	"	10
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			0.15			0.3			1.05
			0.15			0.15			0.15
			0			0.15			0.3
			0			0.15			0

Table A21 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM T-K (B)

BEFORE SOAKING BULK DENSITIES						
Mould No.	N2				N1	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,639		12,617		12359	
Mass of Mould	7,301		7,410		7,473	
Mass of wet sample	5,338		5,207		4,886	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.524		2.462		2.310	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	B1	A24	A23	A18	100	A39
Wet sample + container (g)	82.18	83.59	88.57	80.04	78.24	82.68
Dry sample + container (g)	76.71	78.00	82.65	74.74	73.08	77.17
Mass of container	14.56	14.50	15.32	14.38	14.34	14.27
Mass of water	5.47	5.59	5.92	5.30	5.16	5.51
Mass of dry sample	62.15	63.50	67.33	60.36	58.74	62.90
Water content	8.80	8.80	8.79	8.78	8.78	8.76
Average Water content	8.80		8.79		8.77	
Dry density	**2.32**		**2.26**		**2.12**	
MDD	**2.307**					
Relative Compaction (%)	**101**		**98**		**92**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	74	1.924		69	1.794		45	1.17	
0.50	167	4.342		136	3.536		81	2.106	
0.75	266	6.916		202	5.252		110	2.86	
1.00	365	9.49		267	6.942		138	3.588	
1.25	468	12.168	211	330	8.58	114	166	4.316	53
1.50	573	14.898		380	9.88		192	4.992	
1.75	682	17.732		445	11.57		210	5.46	
2.00	782	20.332		484	12.584		232	6.032	
2.25	880	22.88		530	13.78		251	6.526	
2.50	975	25.35		582	15.132		271	7.046	
2.75	1061	27.586		623	16.198		290	7.54	
3.00	1150	29.9		668	17.368		307	7.982	
3.50	1313	34.138		755	19.63		339	8.814	
4.00	1468	38.168		834	21.684		371	9.646	
4.50	1615	41.99		910	23.66		400	10.4	
5.00	1752	45.552	237	986	25.636	128	428	11.128	56
				1057	27.482		455	11.83	
				1125	29.25		481	12.506	
				1198	31.148		505	13.13	
				1258	32.708		529	13.754	

Table A22 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM T-K (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A3		A7		A4	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,640		12,362		12107	
Mass of Mould	7,433		7,407		7,512	
Mass of wet sample	5,207		4,955		4,595	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.462		2.343		2.173	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	B2	A12	A25	K1	A3	E5
Wet sample + container (g)	78.73	77.85	95.24	97.42	79.05	84.09
Dry sample + container (g)	73.61	72.70	88.69	90.87	73.91	78.53
Mass of container	15.31	14.26	14.24	16.26	15.43	15.17
Mass of water	5.12	5.15	6.55	6.55	5.14	5.56
Mass of dry sample	58.30	58.44	74.45	74.61	58.48	63.36
Water content	8.78	8.81	8.80	8.78	8.79	8.78
Average Water content	8.80		8.79		8.78	
Dry density	**2.26**		**2.15**		**2.00**	
MDD	**2.333**					
Relative Compaction (%)	**97**		**92**		**86**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12,717		12,421		12,236	
Mass of mould	7,433		7,407		7,512	
Mass of wet sample	5,284		5,014		4,724	
Bulk density (g/cc)	2.50		2.37		2.23	
AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A41	A12	K2	B1	A18	A23
Wet sample + container (g)	83.77	86.81	86.23	79.06	81.48	92.14
Dry sample + container (g)	77.79	80.46	80.15	73.28	74.75	84.15
Mass of container	14.21	14.24	14.80	14.58	14.39	15.32
Mass of water	5.98	6.35	6.08	5.78	6.73	7.99
Mass of dry sample	63.58	66.22	65.35	58.70	60.36	68.83
Water content	9.41	9.59	9.30	9.85	11.15	11.38
Average Water content	9.50		9.58		11.38	
Dry density	**2.28**		**2.16**		**2.01**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	65	1.69		34	0.884		26	0.676	
0.50	114	2.964		71	1.846		47	1.222	
0.75	166	4.316		105	2.73		68	1.768	
1.00	222	5.772		166	4.316		87	2.262	
1.25	288	7.488	126	215	5.59	104	103	2.678	35
1.50	353	9.178		266	6.916		120	3.12	
1.75	419	10.894		316	8.216		135	3.51	
2.00	482	12.532		365	9.49		148	3.848	
2.25	544	14.144		410	10.66		162	4.212	
2.50	604	15.704		457	11.882		176	4.576	
2.75	667	17.342		504	13.104		188	4.888	
3.00	728	18.928		548	14.248		198	5.148	
3.50	847	22.022		640	16.64		221	5.746	
4.00	967	25.142		714	18.564		243	6.318	
4.50	1083	28.158		793	20.618		262	6.812	
5.00	1187	30.862	160	880	22.88	121	278	7.228	36
5.50	1278	33.228		943	24.518		297	7.722	
6.00	1366	35.516		1004	26.104		314	8.164	
				1070	27.82		328	8.528	
				1125	29.25		343	8.918	

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	7/6/2001	3:00 PM	0	7/6/2001	3:00 PM	0	7/6/2001	3:00 PM	0
	8/6/2001	"	6	8/6/2001	"	3	8/6/2001	"	3
	9/6/2001	"	6	9/6/2001	"	3	9/6/2001	"	3
	10/6/2001	"	7	10/6/2001	"	3	10/6/2001	"	3
	11/6/2001	"	7	11/6/2001	"	3	11/6/2001	"	3
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			0.9			0.45			0.45
			0			0			0
			0.15			0			0
			0			0			0

Table A22 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM T-K (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A1		6		A7	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,708		12,607		12273	
Mass of Mould	7,488		7,492		7,514	
Mass of wet sample	5,220		5,115		4,759	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.468		2.418		2.250	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A41	E2	B3	A9	B6	A5
Wet sample + container (g)	75.35	72.70	82.19	84.12	77.68	82.18
Dry sample + container (g)	70.41	68.01	76.78	78.48	72.56	76.70
Mass of container	14.20	14.74	15.28	14.28	14.28	14.18
Mass of water	4.94	4.69	5.41	5.64	5.12	5.48
Mass of dry sample	56.21	53.27	61.50	64.20	58.28	62.52
Water content	8.79	8.80	8.80	8.79	8.79	8.77
Average Water content	8.80		8.79		8.78	
Dry density	2.27		2.22		2.07	
MDD	2.333					
Relative Compaction (%)	97		95		89	

Proving Ring constant:kN/div 0.026

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	18	0.468		45	1.17		45	1.17	
0.50	43	1.118		88	2.288		78	2.028	
0.75	72	1.872		134	3.484		111	2.886	
1.00	102	2.652		178	4.628		140	3.64	
1.25	137	3.562		225	5.85		168	4.368	
1.50	176	4.576	102	273	7.098	90	200	5.2	59
1.75	221	5.746		322	8.372		226	5.876	
2.00	278	7.228		368	9.568		253	6.578	
2.25	338	8.788		414	10.764		275	7.15	
2.50	398	10.348		460	11.96		300	7.8	
2.75	462	12.012		508	13.208		320	8.32	
3.00	521	13.546		550	14.3		340	8.84	
3.50	638	16.588		634	16.484		379	9.854	
4.00	752	19.552		713	18.538		414	10.764	
4.50	864	22.464		792	20.592		445	11.57	
5.00	976	25.376		865	22.49		478	12.428	
5.50	1087	28.262	142	938	24.388	113	521	13.546	62
6.00	1187	30.862		1014	26.364		540	14.04	
6.50	1278	33.228		1076	27.976		570	14.82	
7.00	1366	35.516		1139	29.614		595	15.47	
7.50									
8.00									

Table A23 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM JZ-Y (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A2		2		A5	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,429		12,470		12,067	
Mass of Mould	7,340		7,523		7,458	
Mass of wet sample	5,089		4,947		4,609	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.406		2.339		2.179	
BEFORE SOAKING DRY DENSITIES						
Test.	1	2	1	2	1	2
Container No.	C14	D5	C18	D4	D13	D10
Wet sample + container (g)	95.32	87.90	89.55	99.30	95.83	100.40
Dry sample + container (g)	88.75	82.12	83.54	92.53	89.43	93.45
Mass of container	17.96	17.97	17.68	18.21	18.30	18.11
Mass of water	6.57	5.78	6.01	6.77	6.40	6.95
Mass of dry sample	70.79	64.15	65.86	74.32	71.13	75.34
Water content	9.28	9.01	9.13	9.11	9.00	9.22
Average Water Content	9.15		9.12		9.11	
Dry density	**2.20**		**2.14**		**2.00**	
MDD	**2.23**					
Relative density (%)	**99**		**96**		**90**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12512		12584		12231	
Mass of mould	7340		7523		7458	
Mass of wet sample	5172		5061		4773	
Bulk density (g/cc)	2.45		2.39		2.26	
AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	D9	DC11	X6	D7	D8	XY1
Wet sample + container (g)	102.03	98.30	97.53	105.14	108.50	98.60
Dry sample + container (g)	94.30	90.78	89.92	96.04	98.84	90.18
Mass of container	18.08	18.12	18.39	17.85	18.00	18.42
Mass of water	7.73	7.52	7.61	9.10	9.66	8.42
Mass of dry sample	76.22	72.66	71.53	78.19	80.84	71.76
Water content	10.14	10.35	10.64	11.64	11.95	11.73
Average Water content	10.25		11.14		11.84	
Dry density	2.22		2.15		2.02	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55-Blows/Layer			25-Blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	12	0.312		39	1.014		44	1.144	
0.50	24	0.624		71	1.846		68	1.768	
0.75	47	1.222		104	2.704		86	2.236	
1.00	70	1.82		138	3.588		101	2.626	
1.25	95	2.47	63	166	4.316	56	114	2.964	36
1.50	121	3.146		191	4.966		128	3.328	
1.75	147	3.822		214	5.564		140	3.64	
2.00	176	4.576		239	6.214		154	4.004	
2.25	207	5.382		258	6.708		169	4.394	
2.50	240	6.24		284	7.384		181	4.706	
2.75	271	7.046		304	7.904		194	5.044	
3.00	301	7.826		326	8.476		206	5.356	
3.50	361	9.386		370	9.62		229	5.954	
4.00	419	10.894		414	10.764		249	6.474	
4.50	473	12.298		455	11.83		268	6.968	
5.00	525	13.65	77	494	12.844	64	288	7.488	38
5.50	571	14.846		532	13.832		307	7.982	
6.00	617	16.042		564	14.664		323	8.398	
6.50	663	17.238		600	15.6		336	8.736	
7.00	710	18.46		632	16.432		352	9.152	
7.50									
8.00									

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	18/4/00	3:00 PM	0	18/4/00	3:00 PM	0		3:00 PM	0
	19/4/00	"	4	19/4/00	"	5	19/4/00	"	3
	20/4/00	"	4.5	20/4/00	"	5	20/4/00	"	3
	21/4/00	"	5	21/4/00	"	6	21/4/00	"	3
	22/4/00	"	6	22/4/00	"	7	22/4/00	"	3
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			0.6			0.75			0.45
			0.075			0			0
			0.075			0.15			0
			0.15			0.15			0

Table A23 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM JZ-Y (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	6		A3		A1	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,661		12,252		11966	
Mass of Mould	7,535		7,348		7,351	
Mass of wet sample	5,126		4,904		4,615	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	**2.424**		**2.319**		**2.182**	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	C4	X10	112	X3	X5	D11
Wet sample + container (g)	89.21	90.37	96.62	98.19	75.73	80.72
Dry sample + container (g)	83.23	84.30	90.04	91.47	70.92	75.51
Mass of container	18.24	17.62	17.89	17.85	18.26	17.88
Mass of water	5.98	6.07	6.58	6.72	4.81	5.21
Mass of dry sample	64.99	66.68	72.15	73.62	52.66	57.63
Water content	9.20	9.10	9.12	9.13	9.13	9.04
Average Water content	9.15		9.12		9.09	
Dry density	**2.22**		**2.12**		**2.00**	
MDD	**2.23**					
Relative density (%)	**100**		**95**		**90**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	20	0.52		44	1.144		47	1.222	
0.50	39	1.014		95	2.47		81	2.106	
0.75	60	1.56		148	3.848		109	2.834	
1.00	90	2.34		201	5.226		138	3.588	
1.25	114	2.964	65	258	6.708	96	162	4.212	54
1.50	141	3.666		311	8.086		185	4.81	
1.75	170	4.42		361	9.386		208	5.408	
2.00	199	5.174		407	10.582		234	6.084	
2.25	228	5.928		450	11.7		253	6.578	
2.50	259	6.734		488	12.688		274	7.124	
2.75	288	7.488		525	13.65		294	7.644	
3.00	317	8.242		556	14.456		312	8.112	
3.50	376	9.776		627	16.302		339	8.814	
4.00	439	11.414		679	17.654		369	9.594	
4.50	498	12.948		740	19.24		395	10.27	
5.00	560	14.56	82	784	20.384	102	421	10.946	55
5.50	615	15.99		831	21.606		447	11.622	
6.00	674	17.524		880	22.88		471	12.246	
6.50									
7.00									

Table A24 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM L-BP (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	B2		4		6	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,409		11,989		11,752	
Mass of Mould	7,525		7,455		7,625	
Mass of wet sample	4,884		4,534		4,127	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.309		2.144		1.951	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A34	E1	A22	B2	100	A50
Wet sample + container (g)	83.56	74.40	71.60	81.13	91.14	104.60
Dry sample + container (g)	77.94	69.54	67.01	75.80	85.02	97.43
Mass of container	14.12	14.29	14.78	14.94	14.36	14.34
Mass of water	5.62	4.86	4.59	5.33	6.12	7.17
Mass of dry sample	63.82	55.25	52.23	60.86	70.66	83.09
Water content	8.81	8.80	8.79	8.76	8.66	8.63
Average Water content	8.80		8.77		8.65	
Dry density	**2.122**		**1.971**		**1.796**	
MDD	**2.188**					
Relative Compaction (%)	**97**		**90**		**82**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12,607		12,278		12,121	
Mass of mould	7,525		7,455		7,625	
Mass of wet sample	5082		4823		4496	
Bulk density (g/cc)	2.40		2.28		2.13	
AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A20	A9	A2	A41	E5	A32
Wet sample + container (g)	80.70	74.14	80.74	65.50	77.12	86.87
Dry sample + container (g)	72.31	66.56	71.57	58.42	67.61	75.81
Mass of container	14.52	14.29	14.36	14.22	15.21	14.77
Mass of water	8.39	7.58	9.17	7.08	9.51	11.06
Mass of dry sample	57.79	52.27	57.21	44.20	52.40	61.04
Water content	14.52	14.50	16.03	16.02	18.15	18.12
Average Water content	14.51		16.02		18.13	
Dry density	2.098		1.965		1.799	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55-Blows/Layer			25-Blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	div	kN		div	kN		div	kN	
0.25	34	0.884		13	0.338		2	0.052	
0.50	69	1.794		16.5	0.429		3	0.078	
0.75	94	2.444		22	0.572		4	0.104	
1.00	125	3.25		26	0.676		5	0.13	
1.25	150	3.9	49	28	0.728	8	6	0.156	2
1.50	170	4.42		30	0.78		7	0.182	
1.75	190	4.94		34	0.884		7.5	0.195	
2.00	209	5.434		36	0.936		8	0.208	
2.25	229	5.954		38.5	1.001		8.5	0.221	
2.50	248	6.448		40.5	1.053		9	0.234	
2.75	271	7.046		44	1.144		10	0.26	
3.00	285	7.41		46	1.196		10.5	0.273	
3.50	315	8.19		50	1.3		11	0.286	
4.00	340	8.84		55	1.43		13	0.338	
4.50	358	9.308		58.5	1.521		14.5	0.377	
5.00	381	9.906	50	64	1.664	8	16	0.416	2
5.50	398	10.348		65	1.69		17	0.442	
6.00	414	10.764		69	1.794		18	0.468	
6.50	426	11.076		71	1.846		19	0.494	
7.00	439	11.414		74	1.924		20	0.52	
7.50	450	11.7		76	1.976		21	0.546	
8.00	460	11.96		79	2.054		22	0.572	

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	3/12/1999	3:00 PM	0	3/12/1999	3:00 PM	0	3/12/1999	3:00 PM	0
	4/12/1999	"	48	4/12/1999	"	56	4/12/1999	"	58
	5/12/1999	"	53	5/12/1999	"	68	5/12/1999	"	61
	6/12/1999	"	54	6/12/1999	"	79	6/12/1999	"	66
	7/12/1999	"	54	7/12/1999	"	86	7/12/1999	"	66
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			7.2			8.4			8.7
			0.75			1.8			0.45
			0.15			1.65			0.75
			0			1.05			0

Table A24 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM L-BP (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	2		9		A3	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,346		12,002		11513	
Mass of Mould	7,444		7,543		7,374	
Mass of wet sample	4,902		4,459		4,139	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.318		2.108		1.957	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	B4	A31	A40	A8	A38	A18
Wet sample + container (g)	64.52	68.51	82.10	88.03	81.39	77.50
Dry sample + container (g)	60.56	64.13	76.63	82.11	75.97	72.58
Mass of container	15.51	14.35	14.52	14.29	14.28	14.42
Mass of water	3.96	4.38	5.47	5.92	5.42	4.92
Mass of dry sample	45.05	49.78	62.11	67.82	61.69	58.16
Water content	8.79	8.80	8.81	8.73	8.79	8.46
Average Water content	8.79		8.77		8.62	
Dry density	**2.13**		**1.94**		**1.80**	
MDD	**2.188**					
Relative Compaction (%)	**97**		**89**		**82**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	133	3.458		94	2.444		70	1.82	
0.50	290	7.54		159	4.134		93	2.418	
0.75	421	10.946		220	5.72		112	2.912	
1.00	490	12.74		255	6.63		125	3.25	
1.25	565	14.69	170	278	7.228	76	134	3.484	36
1.50	646	16.796		307	7.982		140	3.64	
1.75	719	18.694		338	8.788		156	4.056	
2.00	770	20.02		354	9.204		163	4.238	
2.25	823	21.398		372	9.672		173	4.498	
2.50	865	22.49		388	10.088		185	4.81	
2.75	918	23.868		414	10.764		196	5.096	
3.00	963	25.038		430	11.18		203	5.278	
3.50	1050	27.3		462	12.012		218	5.668	
4.00	1136	29.536		495	12.87		234	6.084	
4.50	1207	31.382		525	13.65		248	6.448	
5.00	1266	32.916	165	556	14.456	72	261	6.786	34
5.50	1327	34.502		582	15.132		274	7.124	
6.00		0		608	15.808		288	7.488	
6.50				630	16.38		299	7.774	
7.00				659	17.134		313	8.138	
7.50									
8.00									

Table A25 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM K-A (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	9		5		2	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,792		12,441		11,979	
Mass of Mould	7,608		7,482		7,437	
Mass of wet sample	5,184		4,959		4,542	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.451		2.345		2.147	
BEFORE SOAKING DRY DENSITIES						
Test	1	2	1	2	1	2
Container No.	D3	XY1	C3	X13	C9	X11
Wet sample + container (g)	136.37	110.72	141.05	147.90	85.28	93.05
Dry sample + container (g)	128.13	104.26	132.56	138.80	80.61	87.82
Mass of container	18.25	18.42	18.71	17.74	17.96	17.80
Mass of water	8.24	6.46	8.49	9.10	4.67	5.23
Mass of dry sample	109.88	85.84	113.85	121.06	62.65	70.02
Water content	7.50	7.53	7.46	7.52	7.45	7.47
Average Water content	7.51		7.49		7.46	
Dry density	**2.28**		**2.18**		**2.00**	
MDD	**2.298**					
Relative Compaction (%)	**99**		**95**		**87**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12926		12627		12286	
Mass of mould	7,608		7,482		7,437	
Mass of wet sample	5318		5145		4849	
Bulk density (g/cc)	2.51		2.43		2.29	
AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A1	A39	A15	B1	K2	A
Wet sample + container (g)	84.75	92.22	82.46	92.30	97.29	82.21
Dry sample + container (g)	77.58	84.18	74.98	83.60	85.21	72.31
Mass of container	15.11	14.32	15.35	14.58	14.85	14.79
Mass of water	7.17	8.04	7.48	8.70	12.08	9.90
Mass of dry sample	62.47	69.86	59.63	69.02	70.36	57.52
Water content	11.48	11.51	12.54	12.61	17.17	17.21
Average Water content	11.49		12.57		17.19	
Dry density	2.26		2.16		1.96	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55-Blows/Layer			25-Blows/layer			10 Blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	div	kN		div	kN		div	kN	
0.25	20	0.52		14	0.364		3	0.078	
0.50	35	0.91		22	0.572		4.4	0.1144	
0.75	50	1.3		41	1.066		5	0.13	
1.00	66	1.716		55	1.43		5.5	0.143	
1.25	82	2.132		70	1.82		6	0.156	
1.50	100	2.6	35	84	2.184	24	7	0.182	2
1.75	120	3.12		96	2.496		7.5	0.195	
2.00	138	3.588		107	2.782		8	0.208	
2.25	158	4.108		115	2.99		9	0.234	
2.50	179	4.654		122	3.172		9.5	0.247	
2.75	197	5.122		131	3.406		10	0.26	
3.00	216	5.616		138	3.588		10.2	0.2652	
3.50	247	6.422		153	3.978		11	0.286	
4.00	276	7.176		167	4.342		12	0.312	
4.50	304	7.904		180	4.68		13	0.338	
5.00	337	8.762	44	190	4.94	25	14	0.364	2
5.50	369	9.594		200	5.2		15	0.39	
6.00	395	10.27		209	5.434		16	0.416	
6.50	426	11.076		217	5.642		17	0.442	
7.00	448	11.648		229	5.954		18	0.468	
7.50	479	12.454		238	6.188		19.5	0.507	
8.00	502	13.052		243	6.318		20.2	0.5252	

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	6/5/2000	3:00 PM	0	6/5/2000	3:00 PM	0	6/5/2000	3:00 PM	0
	7/5/2000	"	45	7/5/2000	"	50	7/5/2000	"	69
	8/5/2000	"	48	8/5/2000	"	53	8/5/2000	"	69
	9/5/2000	"	56	9/5/2000	"	60	9/5/2000	"	79
	10/5/2000	"	57	10/5/2000	"	62	10/5/2000	"	81
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			6.75			7.5			10.35
			0.45			0.45			0
			1.2			1.05			1.5
			0.15			0.3			0.3

Table A25 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM K-A (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	4		9		1	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,547		12,349		11896	
Mass of Mould	7,453		7,530		7,357	
Mass of wet sample	5,094		4,819		4,539	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.408		2.278		2.146	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	X3	C6	X10	X14	D11	C67
Wet sample + container (g)	97.91	124.71	126.49	110.90	94.88	116.74
Dry sample + container (g)	92.33	117.25	118.90	104.44	89.51	109.91
Mass of container	17.85	17.77	17.62	17.82	17.90	18.19
Mass of water	5.58	7.46	7.59	6.46	5.37	6.83
Mass of dry sample	74.48	99.48	101.28	86.62	71.61	91.72
Water content	7.49	7.50	7.49	7.46	7.50	7.45
Average Water content	7.50		7.48		7.47	
Dry density	**2.24**		**2.12**		**2.00**	
MDD	**2.298**					
Relative Compaction (%)	**97**		**92**		**87**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	div	kN		div	kN		div	kN	
0.25	185	4.81		144	3.744		33	0.858	
0.50	342	8.892		224	5.824		58	1.508	
0.75	457	11.882		284	7.384		85	2.21	
1.00	545	14.17		326	8.476		104	2.704	
1.25	620	16.12		364	9.464		121	3.146	
1.50	683	17.758	174	398	10.348	98	136	3.536	37
1.75	741	19.266		428	11.128		150	3.9	
2.00	794	20.644		453	11.778		163	4.238	
2.25	841	21.866		477	12.402		176	4.576	
2.50	888	23.088		498	12.948		187	4.862	
2.75	932	24.232		520	13.52		198	5.148	
3.00	972	25.272		546	14.196		211	5.486	
3.50	1039	27.014		573	14.898		234	6.084	
4.00	1104	28.704		604	15.704		255	6.63	
4.50	1166	30.316		638	16.588		275	7.15	
5.00	1227	31.902	160	665	17.29	87	294	7.644	38
5.50	1285	33.41		690	17.94		311	8.086	
6.00	1340	34.84		707	18.382		328	8.528	
6.50				741	19.266		350	9.1	
7.00				764	19.864		455	11.83	
7.50									
8.00									

Table A26 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM GR (B)

BEFORE SOAKING BULK DENSITIES						
Mould No.			A7		A8	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,640		12,362		12071	
Mass of Mould	7,433		7,407		7,350	
Mass of wet sample	5,207		4,955		4,721	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.462		2.343		2.232	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	B3	A28	A8	A11	A30	A37
Wet sample + container (g)	89.88	98.32	92.85	82.64	89.25	91.13
Dry sample + container (g)	84.36	92.09	87.04	77.63	83.76	85.57
Mass of container	15.31	14.26	14.27	14.99	15.02	15.68
Mass of water	5.52	6.23	5.81	5.01	5,49	5.56
Mass of dry sample	69.05	77.83	72.77	62.64	68.74	69.89
Water content	7.99	8.00	7.98	8.00	7.99	7.96
Average Water content	8.00		7.99		7.97	
Dry density	**2.28**		**2.17**		**2.07**	
MDD	**2.194**					
Relative Compaction (%)	**104**		**99**		**94**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12700		12452		12212	
Mass of mould	7,433		7,407		7,350	
Mass of wet sample	5,267		5,045		4,862	
Bulk density (g/cc)	2.49		2.39		2.30	
AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A5	E4	A14	A50	100	A38
Wet sample + container (g)	99.89	95.47	98.14	85.67	102.72	104.93
Dry sample + container (g)	92.25	88.24	90.26	78.94	94.33	96.36
Mass of container	14.20	14.45	14.97	14.31	14.38	14.3
Mass of water	7.64	7.23	7.88	6.73	8.39	8.57
Mass of dry sample	78.05	73.79	75.29	64.63	79.95	82.06
Water content	9.79	9.80	10.47	10.41	10.49	10.44
Average Water content	9.79		10.44		10.47	
Dry density	**2.27**		**2.16**		**2.08**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	22	0.572		40	1.04		32	0.832	
0.50	47	1.222		78	2.028		59	1.534	
0.75	83	2.158		128	3.328		81	2.106	
1.00	130	3.38		186	4.836		103	2.678	
1.25	191	4.966	103	239	6.214	101	126	3.276	39
1.50	236	6.136		283	7.358		138	3.588	
1.75	300	7.8		326	8.476		154	4.004	
2.00	350	9.1		370	9.62		169	4.394	
2.25	405	10.53		410	10.66		182	4.732	
2.50	445	11.57		450	11.7		197	5.122	
2.75	490	12.74		490	12.74		211	5.486	
3.00	543	14.118		527	13.702		223	5.798	
3.50	632	16.432		600	15.6		247	6.422	
4.00	731	19.006		665	17.29		270	7.02	
4.50	825	21.45		730	18.98		296	7.696	
5.00	915	23.79	**129**	781	20.306	**124**	325	8.45	**42**
5.50	1003	26.078		844	21.944		344	8.944	
6.00	1090	28.34		906	23.556		360	9.36	
6.50	1176	30.576		964	25.064		377	9.802	
7.00	1257	32.682		1020	26.52		398	10.348	
7.50				1079	28.054		415	10.79	
8.00				1132	29.432		436	11.336	

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	12/2/2001	4:00 PM	0	12/2/2001	4:00 PM	0	12/2/2001	4:00 PM	0
	13/2/01	"	6	13/2/01	"	3	13/2/01	"	3
	14/2/01	"	6	14/2/01	"	3	14/2/01	"	3
	15/2/01	"	7	15/2/01	"	3	15/2/01	"	3
	16/2/01	"	7	16/2/01	"	3	16/2/01	"	3
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			0.9			0.45			0.45
			0			0			0
			0.15			0			0
			0			0			0

Table A26 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM GR (B)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A2		A9		A4	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,561		12,547		12174	
Mass of Mould	7,334		7,505		7,434	
Mass of wet sample	5,227		5,042		4,740	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.471		2.384		2.241	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A42	AA40	A21	A23	A26	A22
Wet sample + container (g)	92.67	87.31	92.31	66.74	101.35	93.42
Dry sample + container (g)	86.91	81.91	86.52	62.95	94.86	87.60
Mass of container	14.88	14.37	14.15	15.40	13.20	14.75
Mass of water	5.76	5.40	5.79	3.79	6.49	5.82
Mass of dry sample	72.03	67.54	72.37	47.55	81.66	72.85
Water content	8.00	8.00	8.00	7.97	7.95	7.99
Average Water content	8.00		7.99		7.97	
Dry density	**2.29**		**2.21**		**2.08**	
MDD	**2.194**					
Relative Compaction (%)	**104**		**101**		**95**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	31	0.806		49	1.274		52	1.352	
0.50	58	1.508		99	2.574		83	2.158	
0.75	87	2.262		152	3.952		110	2.86	
1.00	120	3.12		209	5.434		133	3.458	
1.25	153	3.978		268	6.968		153	3.978	
1.50	185	4.81	**81**	328	8.528	**108**	170	4.42	**46**
1.75	225	5.85		383	9.958		188	4.888	
2.00	266	6.916		440	11.44		206	5.356	
2.25	309	8.034		493	12.818		221	5.746	
2.50	350	9.1		549	14.274		236	6.136	
2.75	394	10.244		605	15.73		254	6.604	
3.00	435	11.31		662	17.212		269	6.994	
3.50	522	13.572		764	19.864		302	7.852	
4.00	610	15.86		862	22.412		327	8.502	
4.50	695	18.07		955	24.83		351	9.126	
5.00	775	20.15	**110**	1047	27.222	**136**	379	9.854	**49**
5.50	864	22.464		1141	29.666		403	10.478	
6.00	948	24.648		1225	31.85		430	11.18	
6.50	1040	27.04					453	11.778	
7.00	1114	28.964					481	12.506	
7.50	1195	31.07					500	13	
8.00	1275	33.15					520	13.52	

Table A27 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM A-N (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A6		6		N2	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,347		12,228		11627	
Mass of Mould	7,423		7,526		7,293	
Mass of wet sample	4,924		4,702		4,334	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.328		2.223		2.049	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A	A40	A35	B5	A12	A33
Wet sample + container (g)	87.15	83.13	89.85	87.20	69.19	61.06
Dry sample + container (g)	82.68	78.89	85.17	82.70	65.81	58.18
Mass of container	14.86	14.73	14.30	14.24	14.25	14.54
Mass of water	4.47	4.24	4.68	4.50	3.38	2.88
Mass of dry sample	67.82	64.16	70.87	68.46	51.56	43.64
Water content	6.59	6.61	6.60	6.57	6.56	6.60
Average Water content	6.60		6.59		6.58	
Dry density	**2.18**		**2.09**		**1.92**	
MDD	**2.264**					
Relative Compaction (%)	**96**		**92**		**85**	

AFTER SOAKING BULK DENSITIES			
Wet sample + Mould (g)	12425	12382	11896
Mass of mould	7,423	7,526	7,293
Mass of wet sample	5002	4856	4603
Bulk density (g/cc)	2.36	2.30	2.18

AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A27	K4	A24	A34	A40	E3
Wet sample + container (g)	87.26	97.72	83.42	91.68	88.38	101.20
Dry sample + container (g)	80.35	90.11	75.61	82.84	78.22	90.03
Mass of container	12.92	15.63	14.50	14.09	14.72	15.68
Mass of water	6.91	7.61	7.81	8.84	10.16	11.17
Mass of dry sample	67.43	74.48	61.11	68.75	63.50	74.35
Water content	10.25	10.22	12.78	12.86	16.00	15.02
Average Water content	10.23		12.82		15.51	
Dry density	2.15		2.04		1.88	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer Load (div)	55 -Blows/layer Load (kN)	55 -Blows/layer CBR (%)	25 blows/layer Load div	25 blows/layer Load kN	25 blows/layer CBR (%)	10 blows/layer Load div	10 blows/layer Load kN	10 blows/layer CBR (%)
0.25	29	0.754		21	0.546		5	0.13	
0.50	70	1.82		39	1.014		8	0.208	
0.75	118	3.068		60	1.56		11	0.286	
1.00	166	4.316		78	2.028		12	0.312	
1.25	211	5.486	87	95	2.47	33	14	0.364	4
1.50	261	6.786		115	2.99		16	0.416	
1.75	314	8.164		128	3.328		18	0.468	
2.00	358	9.308		141	3.666		19	0.494	
2.25	401	10.426		156	4.056		21	0.546	
2.50	443	11.518		167	4.342		22	0.572	
2.75	482	12.532		182	4.732		24	0.624	
3.00	522	13.572		195	5.07		25	0.65	
3.50	561	14.586		223	5.798		28	0.728	
4.00	602	15.652		256	6.656		30.5	0.793	
4.50	632	16.432		285	7.41		33.5	0.871	
5.00	678	17.628	88	309	8.034	40	36.5	0.949	5
5.50	750	19.5		331	8.606		39	1.014	
6.00	816	21.216		351	9.126		41	1.066	
6.50	878	22.828		372	9.672		43	1.118	
7.00	930	24.18		375	9.75		46.5	1.209	
7.50	985	25.61		391	10.166		49	1.274	
8.00	1030	26.78		410	10.66		52	1.352	

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	12/2/2001	4:00pm	0	12/2/2001	4:00pm	0	12/2/2001	4:00pm	0
	13/2/01	"	16	13/2/01	"	24	13/2/01	"	32
	14/2/01	"	18	14/2/01	"	24	14/2/01	"	32
	15/2/01	"	18	15/2/01	"	24	15/2/01	"	32
	16/2/01	"	17	16/2/01	"	23	16/2/01	"	32
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			2.4			3.6			4.8
			0.3			0			0
			0			0			0
			-0.15			-0.15			0

Table A27 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM A-N (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A3		B2		A1	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,498		12,271		12,035	
Mass of Mould	7,529		7,543		7,571	
Mass of wet sample	4,969		4,728		4,464	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.349		2.235		2.111	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A42	A25	A27	K4	B6	A16
Wet sample + container (g)	78.33	83.08	91.84	100.93	71.97	76.68
Dry sample + container (g)	74.38	78.83	86.96	95.66	68.42	72.81
Mass of container	14.69	14.25	12.90	15.63	14.29	14.23
Mass of water	3.95	4.25	4.88	5.27	3.55	3.87
Mass of dry sample	59.69	64.58	74.06	80.03	54.13	58.58
Water content	6.62	6.58	6.59	6.59	6.56	6.61
Average Water content	6.60		6.59		6.58	
Dry density	**2.20**		**2.10**		**1.98**	
MDD	**2.264**					
Relative Compaction (%)	**97**		**93**		**87**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	57	1.482		40	1.04		59	1.534	
0.50	101	2.626		101	2.626		98	2.548	
0.75	150	3.9		183	4.758		125	3.25	
1.00	207	5.382		265	6.89		142	3.692	
1.25	268	6.968	106	318	8.268	107	165	4.29	47
1.50	327	8.502		362	9.412		185	4.81	
1.75	383	9.958		407	10.582		200	5.2	
2.00	439	11.414		445	11.57		209	5.434	
2.25	488	12.688		481	12.506		224	5.824	
2.50	538	13.988		517	13.442		237	6.162	
2.75	587	15.262		550	14.3		250	6.5	
3.00	633	16.458		582	15.132		264	6.864	
3.50	721	18.746		640	16.64		294	7.644	
4.00	810	21.06		701	18.226		319	8.294	
4.50	902	23.452		759	19.734		345	8.97	
5.00	992	25.792	129	814	21.164	109	368	9.568	48
5.50	1062	27.612		867	22.542		388	10.088	
6.00	1140	29.64		919	23.894		409	10.634	
6.50	1212	31.512		968	25.168		432	11.232	
7.00	1289	33.514		1008	26.208		455	11.83	
7.50							477	12.402	
8.00							497	12.922	

Table A28 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM JB (B)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A8		A2		A7	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,354		12,081		11847	
Mass of Mould	7,431		7,346		7,408	
Mass of wet sample	4,923		4,735		4,439	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.328		2.239		2.099	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A23	AA40	A11	B3	A26	A37
Wet sample + container (g)	73.10	75.52	76.56	73.95	83.32	88.57
Dry sample + container (g)	69.23	71.41	72.43	70.03	78.62	83.70
Mass of container	15.37	14.35	15.00	15.31	13.20	15.67
Mass of water	3.87	4.11	4.13	3.92	4.70	4.87
Mass of dry sample	53.86	57.06	57.43	54.72	65.42	68.03
Water content	7.19	7.20	7.19	7.16	7.18	7.16
Average Water content	7.19		7.18		7.17	
Dry density	**2.17**		**2.09**		**1.96**	
MDD	**2.174**					
Relative Compaction (%)	**100**		**96**		**90**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12391		12142		11970	
Mass of mould	7,431		7,346		7,408	
Mass of wet sample	4,960		4,796		4,562	
Bulk density (g/cc)	2.35		2.27		2.16	
AFTER SOAKING DRY DENSITIES						
	TOP	BOT	TOP	BOT	TOP	BOT
Container No.	A22	A11	A23	B3	AA40	A37
Wet sample + container (g)	86.35	80.95	100.41	98.2	94.63	96.32
Dry sample + container (g)	80.90	75.91	92.03	90.00	83.96	85.64
Mass of container	14.74	14.99	15.37	15.31	14.35	15.66
Mass of water	5.45	5.04	8.38	8.20	10.67	10.68
Mass of dry sample	66.16	60.92	76.66	74.69	69.61	69.98
Water content	8.24	8.27	10.93	10.98	15.33	15.26
Average Water content	8.26		10.96		15.29	
Dry density	**2.17**		**2.04**		**1.87**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	22	0.572		27	0.702		11	0.286	
0.50	40	1.04		51	1.326		18	0.468	
0.75	63	1.638		78	2.028		25	0.65	
1.00	87	2.262		105	2.73		29	0.754	
1.25	113	2.938		131	3.406		34	0.884	
1.50	139	3.614	47	160	4.16	71	37	0.962	11
1.75	165	4.29		190	4.94		41	1.066	
2.00	187	4.862		237	6.162		45	1.17	
2.25	211	5.486		270	7.02		51	1.326	
2.50	237	6.162		291	7.566		55	1.43	
2.75	262	6.812		318	8.268		60	1.56	
3.00	288	7.488		343	8.918		65	1.69	
3.50	332	8.632		391	10.166		74	1.924	
4.00	374	9.724		435	11.31		81	2.106	
4.50	414	10.764		480	12.48		89	2.314	
5.00	450	11.7	59	520	13.52	70	95	2.47	12
5.50	480	12.48		558	14.508		103	2.678	
6.00	507	13.182		595	15.47		111	2.886	
6.50	534	13.884		630	16.38		118	3.068	
7.00	561	14.586		661	17.186		127	3.302	
7.50	587	15.262		693	18.018		135	3.51	
8.00	617	16.042		725	18.85		140	3.64	

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	9/2/2001	2:45PM	0	9/2/2001	2:45PM	0	9/2/2001	2:45PM	0
	10/2/2001	"	52	10/2/2001	"	54	10/2/2001	"	55
	11/2/2001	"	52	11/2/2001	"	54	11/2/2001	"	55
	12/2/2001	"	56	12/2/2001	"	56	12/2/2001	"	56
	13/2/01	"	56	13/2/01	"	56	13/2/01	"	56
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			7.8			8.1			8.25
			0			0			0
			0.6			0.3			0.15
			0			0			0

Table A28 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM JB (B)

BEFORE SOAKING BULK DENSITIES						
Mould No.	N2		6		A6	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,184		12,143		11,717	
Mass of Mould	7,304		7,523		7,434	
Mass of wet sample	4,880		4,620		4,283	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.307		2.184		2.025	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A6	A34	E2	A18	A5	A22
Wet sample + container (g)	69.92	69.09	74.72	72.62	78.23	68.89
Dry sample + container (g)	66.18	65.40	70.71	68.71	73.99	65.27
Mass of container	14.20	14.09	14.77	14.40	14.84	14.75
Mass of water	3.74	3.69	4.01	3.91	4.24	3.62
Mass of dry sample	51.98	51.31	55.94	54.31	59.15	50.52
Water content	7.20	7.19	7.17	7.20	7.17	7.17
Average Water content	7.19		7.18		7.17	
Dry density	**2.15**		**2.04**		**1.89**	
MDD	**2.174**					
Relative Compaction (%)	**99**		**94**		**87**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	div	kN		div	kN		div	kN	
0.25	29	0.754		72	1.872		37	0.962	
0.50	62	1.612		115	2.99		49	1.274	
0.75	107	2.782		153	3.978		62	1.612	
1.00	159	4.134		186	4.836		71	1.846	
1.25	215	5.59	104	217	5.642	67	82	2.132	23
1.50	270	7.02		243	6.318		90	2.34	
1.75	320	8.32		271	7.046		95	2.47	
2.00	368	9.568		298	7.748		98	2.548	
2.25	418	10.868		323	8.398		110	2.86	
2.50	460	11.96		342	8.892		117	3.042	
2.75	506	13.156		367	9.542		124	3.224	
3.00	551	14.326		390	10.14		131	3.406	
3.50	630	16.38		432	11.232		148	3.848	
4.00	714	18.564		473	12.298		160	4.16	
4.50	781	20.306		522	13.572		169	4.394	
5.00	855	22.23	118	555	14.43	72	183	4.758	24
5.50	929	24.154		595	15.47		194	5.044	
6.00	987	25.662		635	16.51		207	5.382	
6.50	1044	27.144		673	17.498		217	5.642	
7.00	1100	28.6		700	18.2		230	5.98	
7.50	1158	30.108		731	19.006		242	6.292	
8.00	1210	31.46		765	19.89		250	6.5	

Table A29 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM AJ-AD (B)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A6		A5		6	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,373		12,168		11643	
Mass of Mould	7,418		7,416		7,384	
Mass of wet sample	4,955		4,752		4,259	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.343		2.247		2.014	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A26	A16	A21	A37	B1	E2
Wet sample + container (g)	87.32	80.04	76.87	72.99	91.53	83.90
Dry sample + container (g)	82.42	75.63	72.67	69.15	86.39	79.27
Mass of container	14.38	14.23	14.17	15.67	14.59	14.77
Mass of water	4.90	4.41	4.20	3.84	5.14	4.63
Mass of dry sample	68.04	61.40	58.50	53.48	71.80	64.50
Water content	7.20	7.18	7.18	7.18	7.16	7.18
Average Water content	7.19		7.18		7.17	
Dry density	**2.19**		**2.10**		**1.88**	
MDD	**2.193**					
Relative Compaction (%)	**100**		**96**		**86**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12416		12257		11987	
Mass of mould	7,418		7,416		7,384	
Mass of wet sample	4998		4841		4603	
Bulk density (g/cc)	2.36		2.29		2.18	
AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A18	A11	A23	A5	B3	A9
Wet sample + container (g)	72.85	73.40	69.47	71.71	91.15	92.32
Dry sample + container (g)	68.74	69.24	65.37	67.37	83.99	85.01
Mass of container	14.40	14.99	15.36	14.83	15.28	14.29
Mass of water	4.11	4.16	4.10	4.34	7.16	7.31
Mass of dry sample	54.34	54.25	50.01	52.54	68.71	70.72
Water content	7.56	7.67	8.20	8.26	10.42	10.34
Average Water content	7.62		8.23		10.38	
Dry density	2.196		2.115		1.972	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	32	0.832		36	0.936		27	0.702	
0.50	48	1.248		77	2.002		48	1.248	
0.75	80	2.08		125	3.25		65	1.69	
1.00	114	2.964		170	4.42		81	2.106	
1.25	151	3.926	89	215	5.59	80	96	2.496	30
1.50	191	4.966		254	6.604		109	2.834	
1.75	235	6.11		296	7.696		122	3.172	
2.00	280	7.28		334	8.684		134	3.484	
2.25	326	8.476		372	9.672		145	3.77	
2.50	373	9.698		409	10.634		154	4.004	
2.75	420	10.92		446	11.596		164	4.264	
3.00	469	12.194		482	12.532		173	4.498	
3.50	567	14.742		550	14.3		192	4.992	
4.00	670	17.42		616	16.016		210	5.46	
4.50	770	20.02		682	17.732		226	5.876	
5.00	870	22.62	124	743	19.318	97	245	6.37	32
5.50	973	25.298		797	20.722		264	6.864	
6.00	1075	27.95		850	22.1		277	7.202	
6.50	1176	30.576		905	23.53		296	7.696	
7.00	1277	33.202		955	24.83		314	8.164	
7.50				1001	26.026		331	8.606	
8.00				1053			346	8.996	

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	25/12/00	3:00pm	0	25/12/00	3:00pm	0	25/12/00	3:00pm	0
	26/12/00	"	4	26/12/00	"	3	26/12/00	"	0
	27/12/00	"	5	27/12/00	"	3	27/12/00	"	1
	28/12/00	"	5	28/12/00	"	3	28/12/00	"	1
	29/12/00	"	6	29/12/00	"	3	29/12/00	"	1
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			0.6			0.45			0
			0.15			0			0.15
			0			0			0
			0.15			0			0

Table A29 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM AJ-AD (B)

BEFORE SOAKING BULK DENSITIES						
Mould No.	A4		6		A8	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,414		12,262		11872	
Mass of Mould	7,438		7,533		7,393	
Mass of wet sample	4,976		4,729		4,479	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.353		2.236		2.118	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A32	A3	A5	A31	A27	A38
Wet sample + container (g)	82.96	76.70	79.68	78.06	73.45	86.03
Dry sample + container (g)	78.39	72.59	75.30	73.79	69.40	81.23
Mass of container	14.79	15.49	14.21	14.35	12.90	14.30
Mass of water	4.57	4.11	4.38	4.27	4.05	4.80
Mass of dry sample	63.60	57.10	61.09	59.44	56.50	66.93
Water content	7.19	7.20	7.17	7.18	7.17	7.17
Average Water content	7.19		7.18		7.17	
Dry density	**2.19**		**2.09**		**1.98**	
MDD	**2.193**					
Relative Compaction (%)	**100**		**95**		**90**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	46	1.196		68	1.768		30	0.78	
0.50	95	2.47		131	3.406		54	1.404	
0.75	150	3.9		184	4.784		76	1.976	
1.00	210	5.46		230	5.98		95	2.47	
1.25	281	7.306	126	279	7.254	97	113	2.938	37
1.50	352	9.152		325	8.45		130	3.38	
1.75	420	10.92		367	9.542		145	3.77	
2.00	490	12.74		409	10.634		161	4.186	
2.25	568	14.768		449	11.674		175	4.55	
2.50	643	16.718		492	12.792		189	4.914	
2.75	718	18.668		531	13.806		201	5.226	
3.00	790	20.54		571	14.846		222	5.772	
3.50	956	24.856		654	17.004		253	6.578	
4.00	1115	28.99		728	18.928		278	7.228	
4.50	1290	33.54		818	21.268		304	7.904	
5.00	1457	37.882	190	885	23.01	115	331	8.606	43
5.50				960	24.96		350	9.1	
6.00				1030	26.78		378	9.828	
6.50				1100	28.6		399	10.374	
7.00				1167	30.342		424	11.024	
7.50									
8.00									

Table A30 a SOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM K-W (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	N1		A4		A5	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,345		12,240		11951	
Mass of Mould	7,468		7,435		7,417	
Mass of wet sample	4,877		4,805		4,534	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.306		2.272		2.144	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A24	A30	A15	E3	E5	A41
Wet sample + container (g)	70.46	61.87	83.85	76.26	72.05	77.70
Dry sample + container (g)	64.88	57.26	77.10	70.27	66.45	71.43
Mass of container	14.51	15.02	15.36	15.68	15.19	14.23
Mass of water	5.58	4.61	6.75	5.99	5.60	6.27
Mass of dry sample	50.37	42.24	61.74	54.59	51.26	57.20
Water content	11.08	10.91	10.93	10.97	10.92	10.96
Average Water content	11.00		10.95		10.94	
Dry density	**2.08**		**2.05**		**1.93**	
MDD	**2.131**					
Relative Compaction (%)	**97**		**96**		**91**	
AFTER SOAKING BULK DENSITIES						
Wet sample + Mould (g)	12383		12300		12064	
Mass of mould	7,468		7,435		7,417	
Mass of wet sample	4915		4865		4647	
Bulk density (g/cc)	2.32		2.30		2.20	
AFTER SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	A26	A28	A42	A8	A30	A21
Wet sample + container (g)	64.03	65.33	69.34	75.80	80.03	88.24
Dry sample + container (g)	58.65	59.96	63.24	68.93	72.19	79.28
Mass of container	13.21	14.26	14.69	14.27	15.02	14.15
Mass of water	5.38	5.37	6.10	6.87	7.84	8.96
Mass of dry sample	45.44	45.70	48.55	54.66	57.17	65.13
Water content	11.84	11.75	12.56	12.57	13.71	13.76
Average Water content	11.80		12.57		13.74	
Dry density	2.08		2.04		1.93	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	23	0.598		21	0.546		24	0.624	
0.50	39	1.014		40	1.04		35	0.91	
0.75	56	1.456		59	1.534		46	1.196	
1.00	73	1.898		76	1.976		59	1.534	
1.25	88	2.288		91	2.366		68	1.768	
1.50	103	2.678	31	105	2.73	30	77	2.002	21
1.75	119	3.094		118	3.068		86	2.236	
2.00	133	3.458		130	3.38		93	2.418	
2.25	147	3.822		142	3.692		99	2.574	
2.50	156	4.056		153	3.978		107	2.782	
2.75	168	4.368		162	4.212		113	2.938	
3.00	180	4.68		171	4.446		119	3.094	
3.50	200	5.2		186	4.836		128	3.328	
4.00	221	5.746		200	5.2		138	3.588	
4.50	240	6.24		214	5.564		146	3.796	
5.00	257	6.682	33	228	5.928	30	154	4.004	20
5.50	275	7.15		240	6.24		160	4.16	
6.00	291	7.566		252	6.552		168	4.368	
6.50	308	8.008		264	6.864		175	4.55	
7.00	323	8.398		275	7.15		182	4.732	
7.50	338	8.788		288	7.488		188	4.888	
8.00	353	9.178		300			190	4.94	

SWELL DATA

	Date	Time	Gauge (div)	Date	Time	Gauge (div)	Date	Time	Gauge (div)
	10/2/2001	3:00pm	0	10/2/2001	3:00pm	0	10/2/2001	3:00pm	0
	11/2/2001	"	52	11/2/2001	"	56	11/2/2001	"	60
	12/2/2001	"	56	12/2/2001	"	58	12/2/2001	"	62
	13/2/01	"	56	13/2/01	"	62	13/2/01	"	64
	14/2/01	"	59	14/2/01	"	62	14/2/01	"	64
		DT	Dh (mm)		DT	Dh (mm)		DT	Dh (mm)
			7.8			8.4			9
			0.6			0.3			0.3
			0			0.6			0.3
			0.45			0			0

Table A30 b UNSOAKED CBR TEST RESULTS ON SOIL SAMPLE FROM K-W (SB)

BEFORE SOAKING BULK DENSITIES						
Mould No.	N2		6		A6	
No. of blows per layer	55		25		10	
Wet sample + Mould (g)	12,166		12,326		11986	
Mass of Mould	7,301		7,521		7,433	
Mass of wet sample	4,865		4,805		4,553	
Volume of mould	2115		2115		2115	
Bulk density (g/cc)	2.300		2.272		2.153	
BEFORE SOAKING DRY DENSITIES						
	1	2	1	2	1	2
Container No.	B2	E6	A2	A8	A21	A28
Wet sample + container (g)	80.98	80.45	80.71	78.02	90.87	94.43
Dry sample + container (g)	74.42	73.92	74.15	71.73	83.30	86.53
Mass of container	14.92	14.45	14.40	14.27	14.16	14.25
Mass of water	6.56	6.53	6.56	6.29	7.57	7.90
Mass of dry sample	59.50	59.47	59.75	57.46	69.14	72.28
Water content	11.03	10.98	10.98	10.95	10.95	10.93
Average Water content	11.00		10.96		10.94	
Dry density	**2.07**		**2.05**		**1.94**	
MDD	**2.131**					
Relative Compaction (%)	**97**		**96**		**91**	

Proving Ring constant:kN/div **0.026**

Penetration (mm)	55 -Blows/layer			25 blows/layer			10 blows/layer		
	Load		CBR (%)	Load		CBR (%)	Load		CBR (%)
	(div)	(kN)		div	kN		div	kN	
0.25	20	0.52		31	0.806		23	0.598	
0.50	32	0.832		55	1.43		41	1.066	
0.75	45	1.17		80	2.08		55	1.43	
1.00	59	1.534		102	2.652		67	1.742	
1.25	73	1.898	25	125	3.25	43	77	2.002	23
1.50	85	2.21		144	3.744		86	2.236	
1.75	96	2.496		163	4.238		95	2.47	
2.00	110	2.86		184	4.784		103	2.678	
2.25	119	3.094		198	5.148		111	2.886	
2.50	129	3.354		217	5.642		118	3.068	
2.75	139	3.614		233	6.058		124	3.224	
3.00	149	3.874		249	6.474		131	3.406	
3.50	168	4.368		278	7.228		143	3.718	
4.00	186	4.836		305	7.93		154	4.004	
4.50	203	5.278		330	8.58		165	4.29	
5.00	219	5.694	29	354	9.204	46	176	4.576	23
5.50	236	6.136		378	9.828		187	4.862	
6.00	252	6.552		397	10.322		198	5.148	
6.50	269	6.994		418	10.868		208	5.408	
7.00	283	7.358		439	11.414		219	5.694	
7.50	299	7.774		459	11.934		225	5.85	
8.00	313	8.138		476	12.376		235	6.11	

Table A31a Atterberg Limits for Labortory Compacted Samples

ZONE	MATERIAL SOURCE	TEST	0 BLOWS			55 BLOWS			25 BLOWS			10 BLOWS		
			LL	PL	PI	LL	PL	PI	LL	PL	PI	LL	PL	PI
1	T-K (B)	1	29	20	9	27	20	7	26	18	8	27	18	9
		2	29	20	9	27	20	7	26	18	8	27	18	9
	T-K (SB)	1	35	23	12	31	18	13	34	20	14	35	20	15
		2	35	23	12	31	18	13	34	20	14	35	20	15
2	JZ - Y (SB)	1	31	16	15	34	17	17	35	16	19	37	16	21
		2	31	16	15	34	17	17	36	16	20	37	16	21
	L-BP (SB)	1	51	26	25	44	22	22	46	22	24	44	22	22
		2	52	26	26	44	21	23	46	23	23	44	21	23
	K-A (SB)	1	36	19	17	42	19	23	43	19	24	43	19	24
		2	36	19	17	42	19	23	43	19	24	43	19	24
	GR (B)	1	33	18	15	32	17	15	32	18	14	32	18	14
		2	32	17	15	33	18	15	33	19	14	32	18	14
	A - N (SB)	1	40	19	21	37	18	19	38	20	18	38	20	18
		2	41	20	21	36	17	19	38	20	18	37	19	18
	JB (B)	1	56	23	33	45	19	26	46	19	27	47	20	27
		2	55	22	33	46	20	26	46	19	27	47	20	27
3	AJ - AD (B)	1	33	16	17	31	16	15	29	15	14	30	15	15
		2	32	15	17	31	16	15	30	15	15	29	15	14
	K - W (SB)	1	36	19	17	42	19	23	43	19	24	43	19	24
		2	36	19	17	42	19	23	43	19	24	43	19	24

Fig. A1 Effect of Laboratory Compactive Effort on Grading for T-K (B) Material.

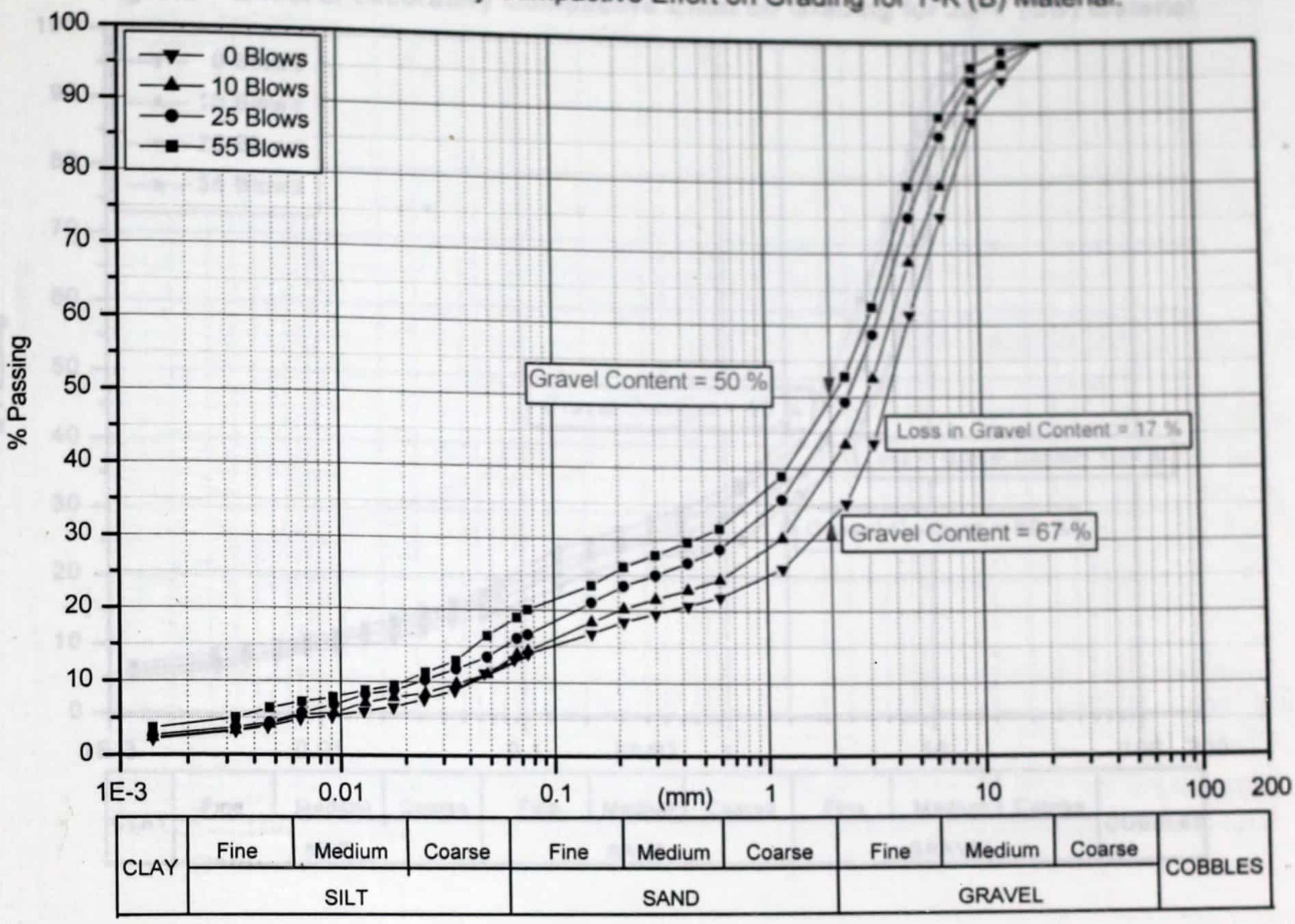


Fig. A2 Effect of Laboratory Compactive Effort on Grading for T-K (SB) Material.

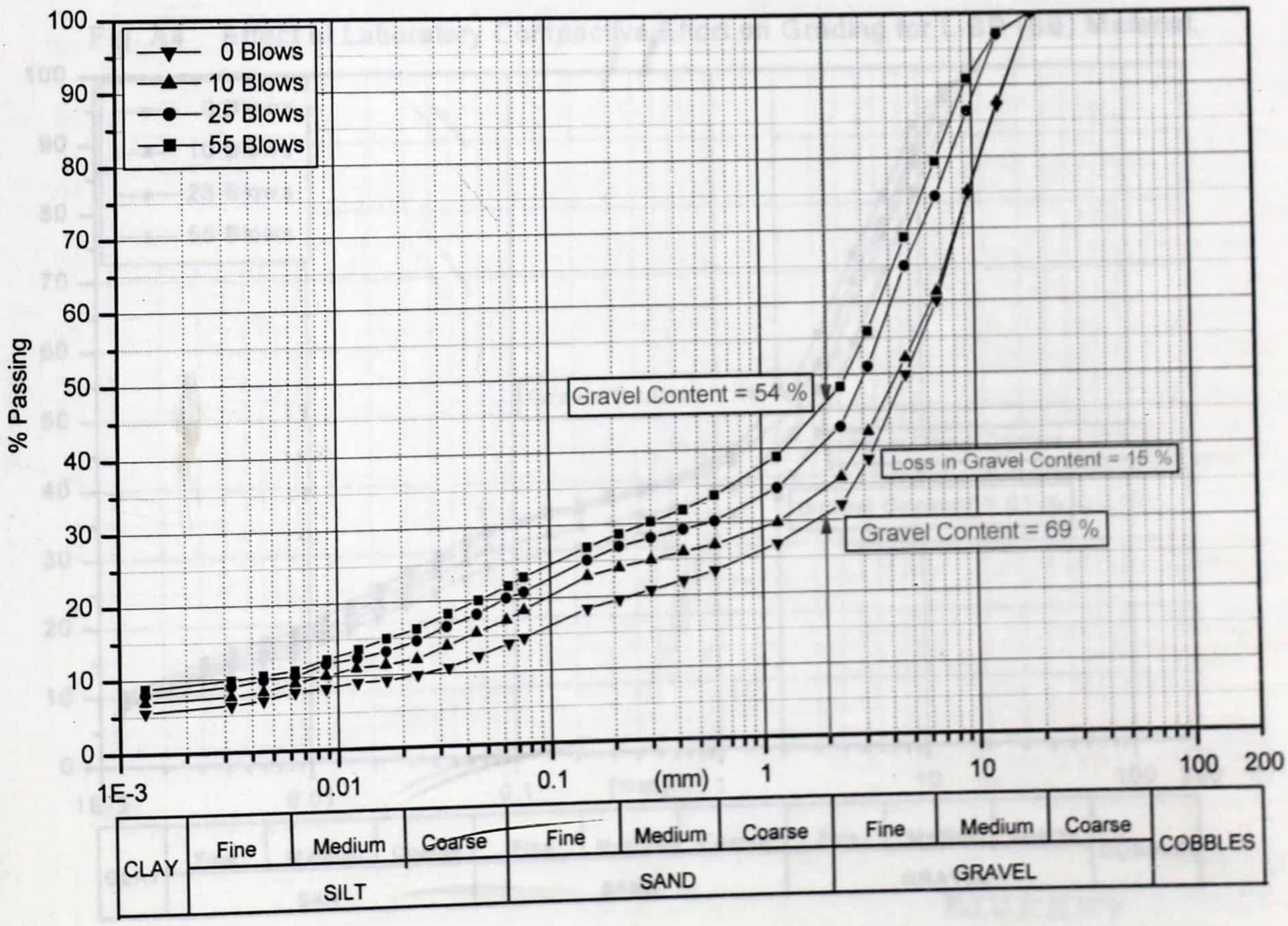


Fig. A3 Effect of Laboratory Compactive Effort on Grading for JZ-Y (SB) Material.

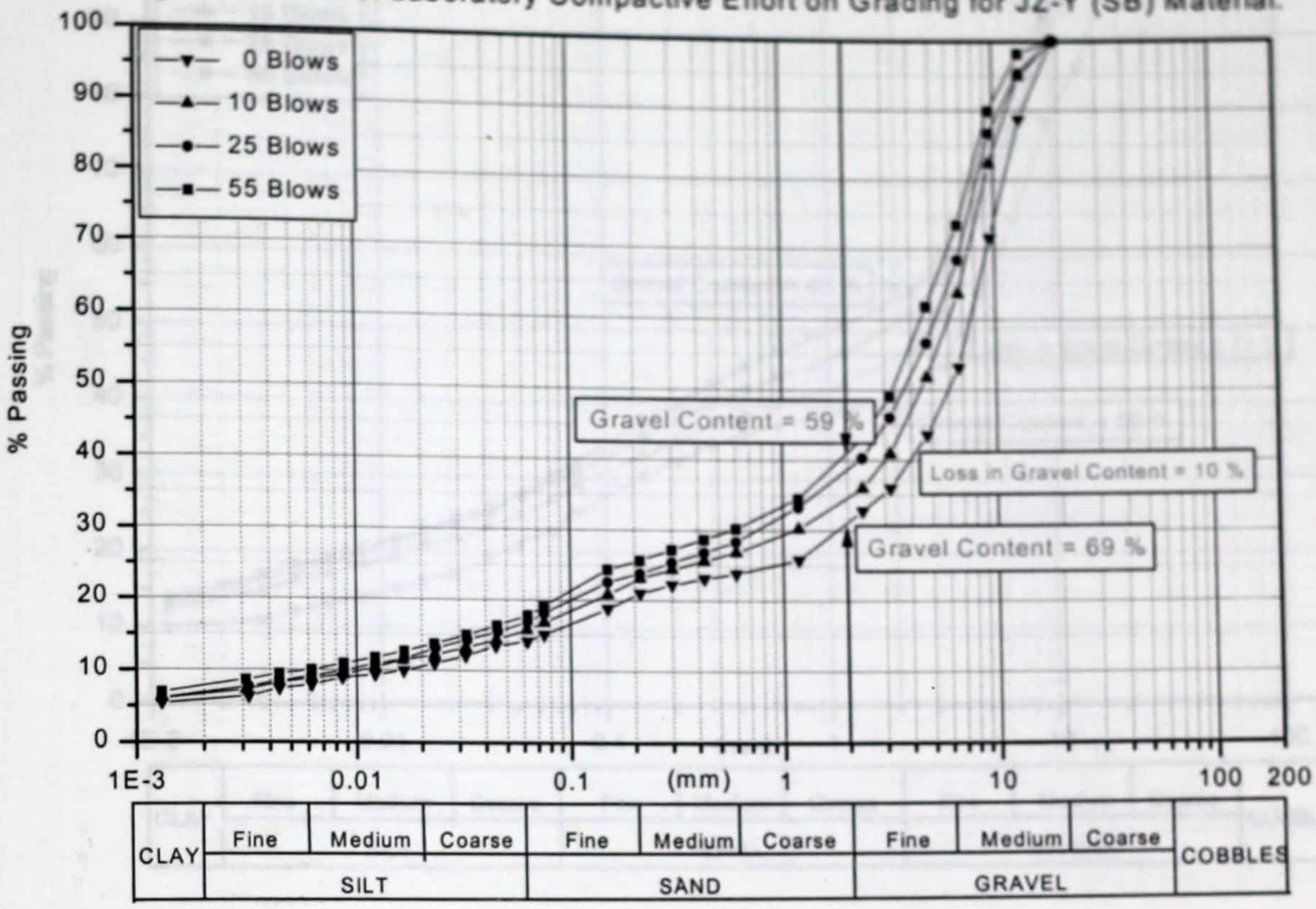


Fig. A4 Effect of Laboratory Compactive Effort on Grading for L-BP (SB) Material.

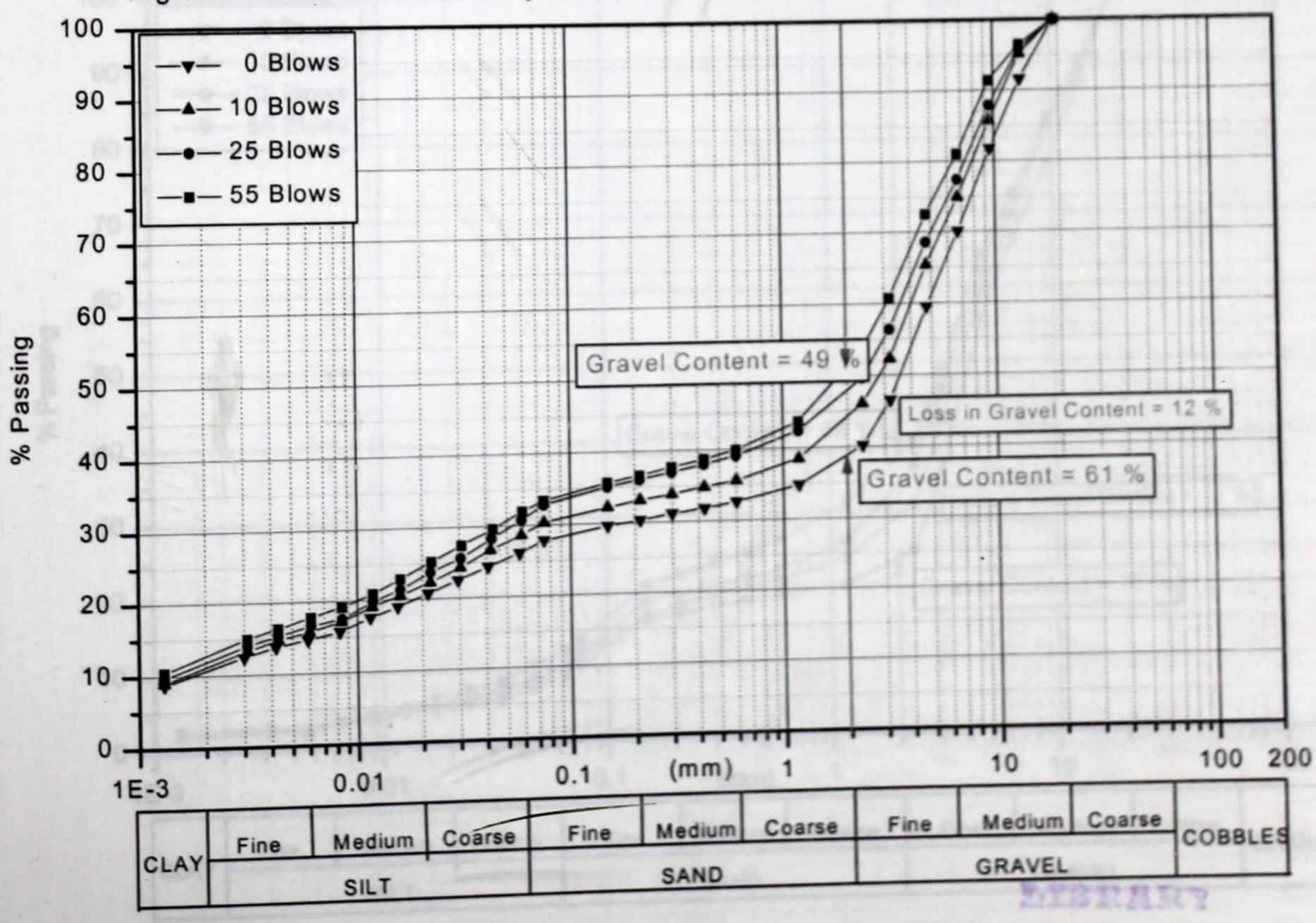


Fig. A5 Effect of Laboratory Compactive Effort on Grading for K-A (SB) Material.

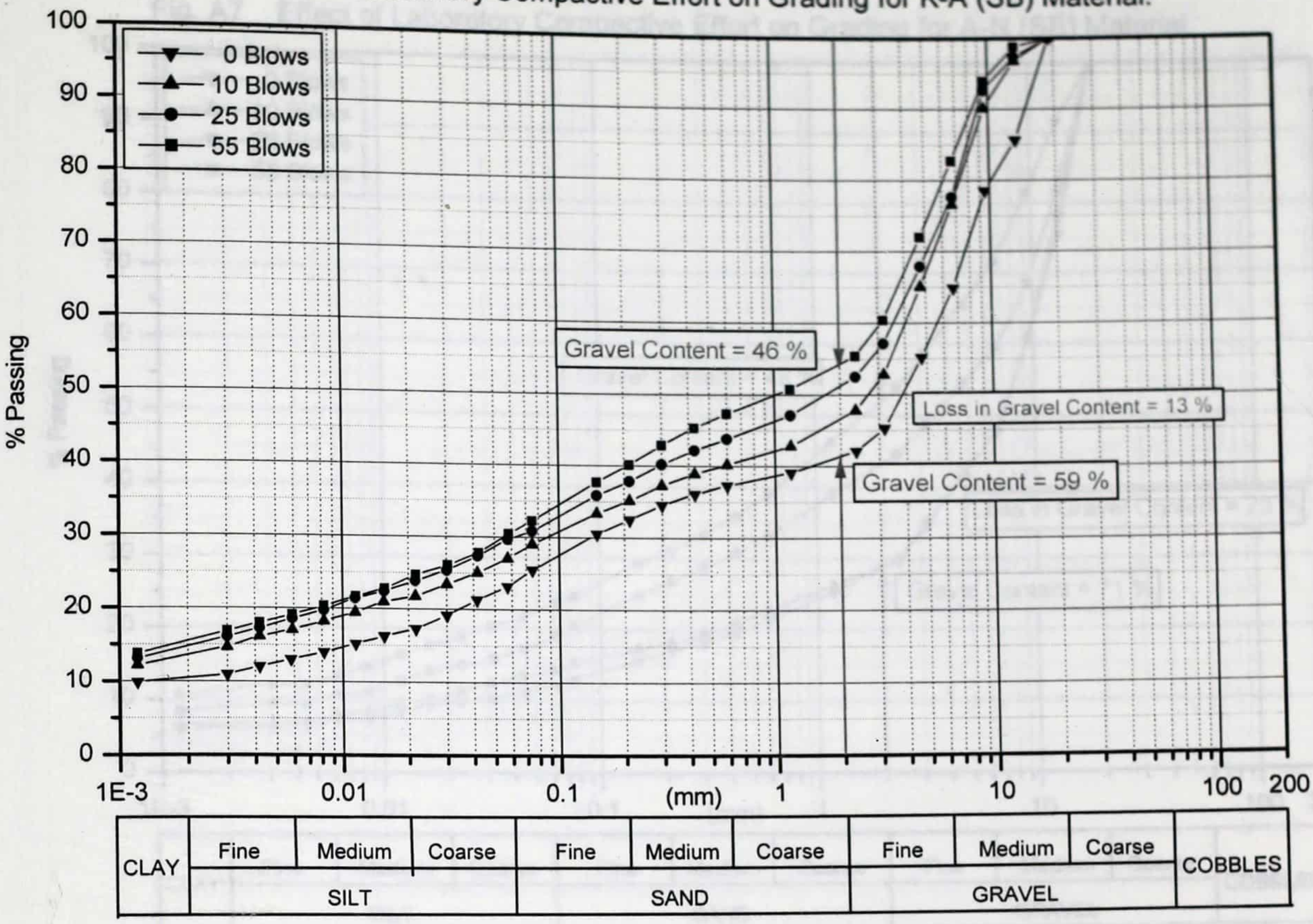


Fig. A6 Effect of Laboratory Compactive Effort on Grading for GR (B) Material.

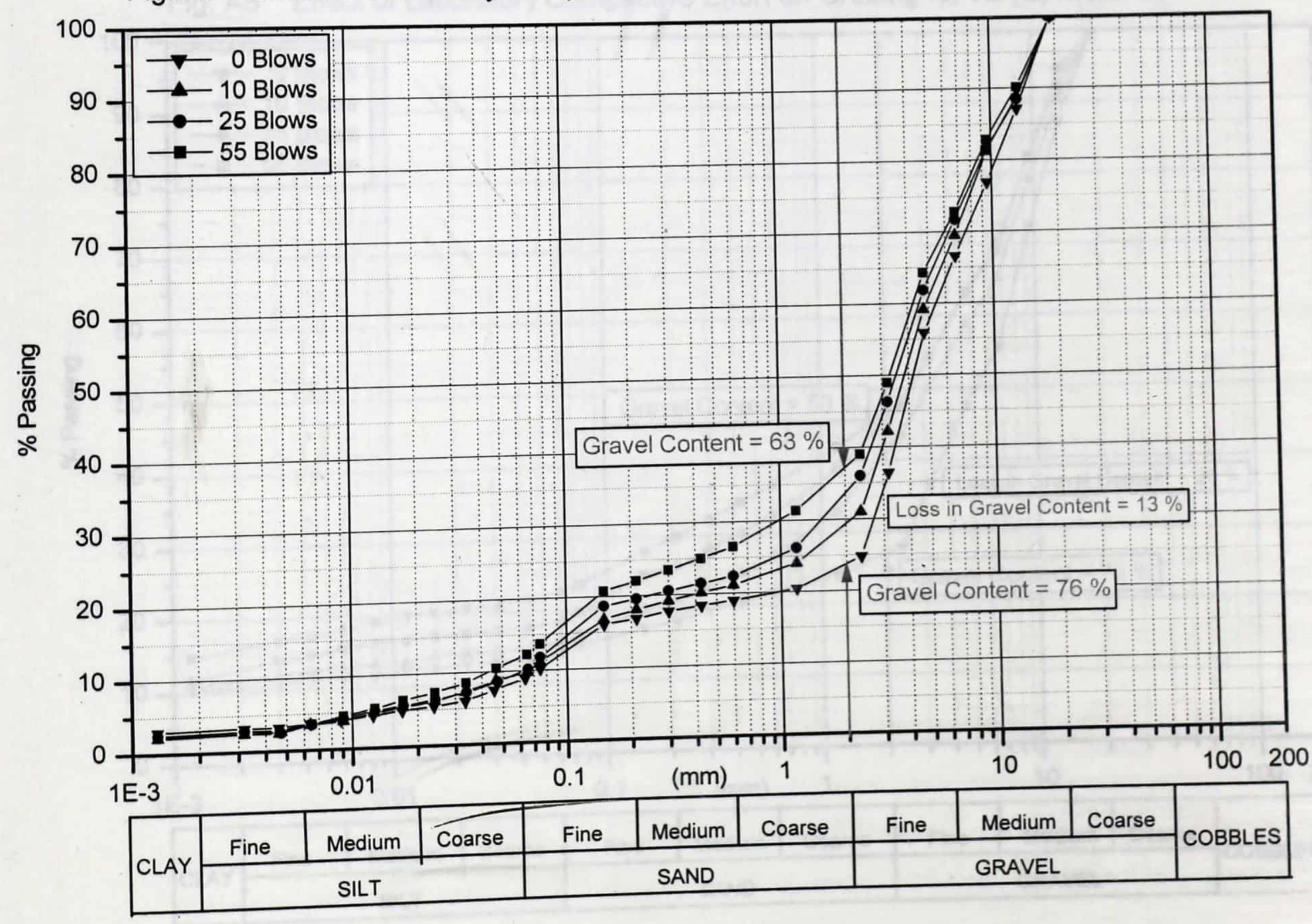


Fig. A7 Effect of Laboratory Compactive Effort on Grading for A-N (SB) Material.

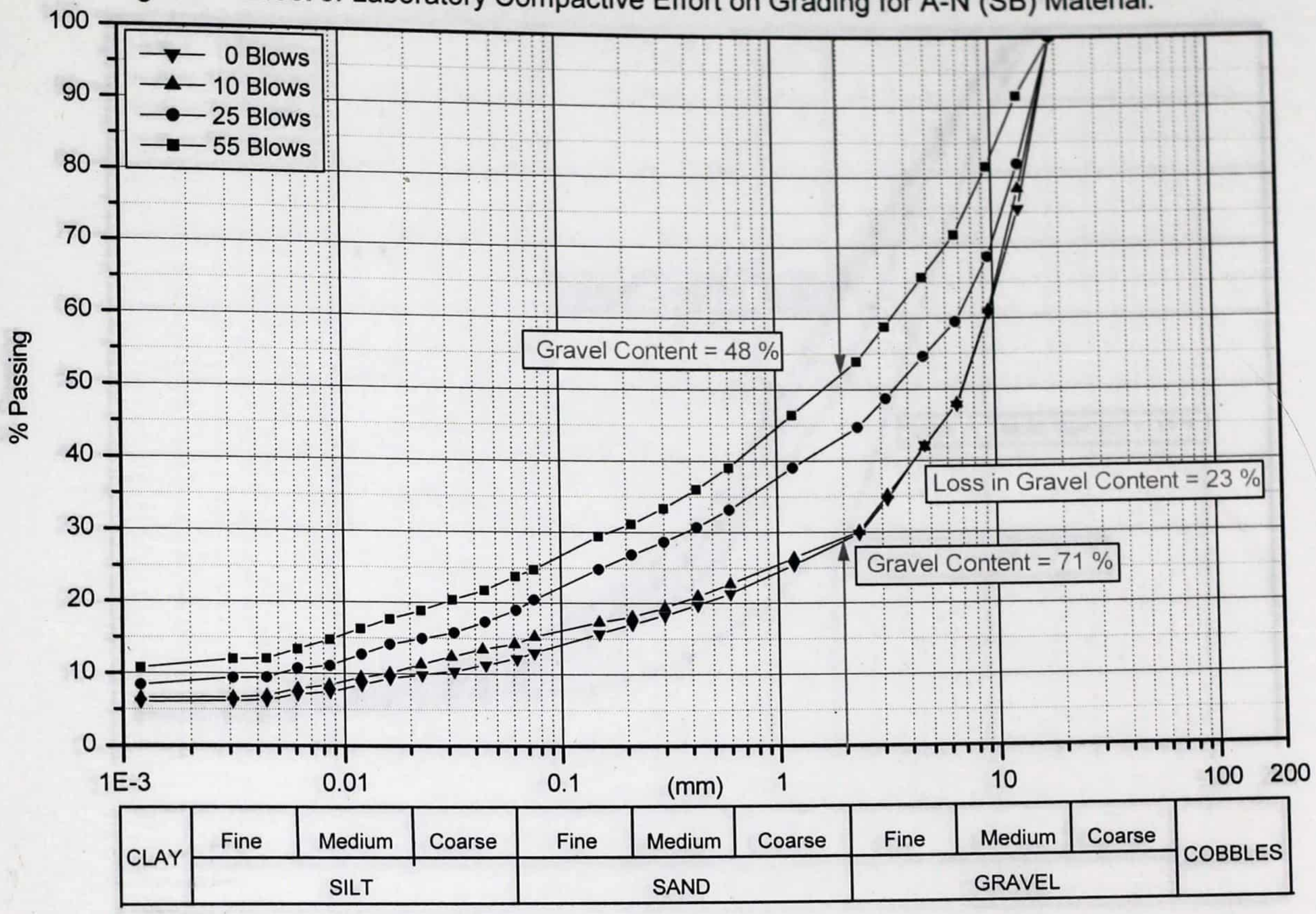


Fig. A8 Effect of Laboratory Compactive Effort on Grading for JB (B) Material.

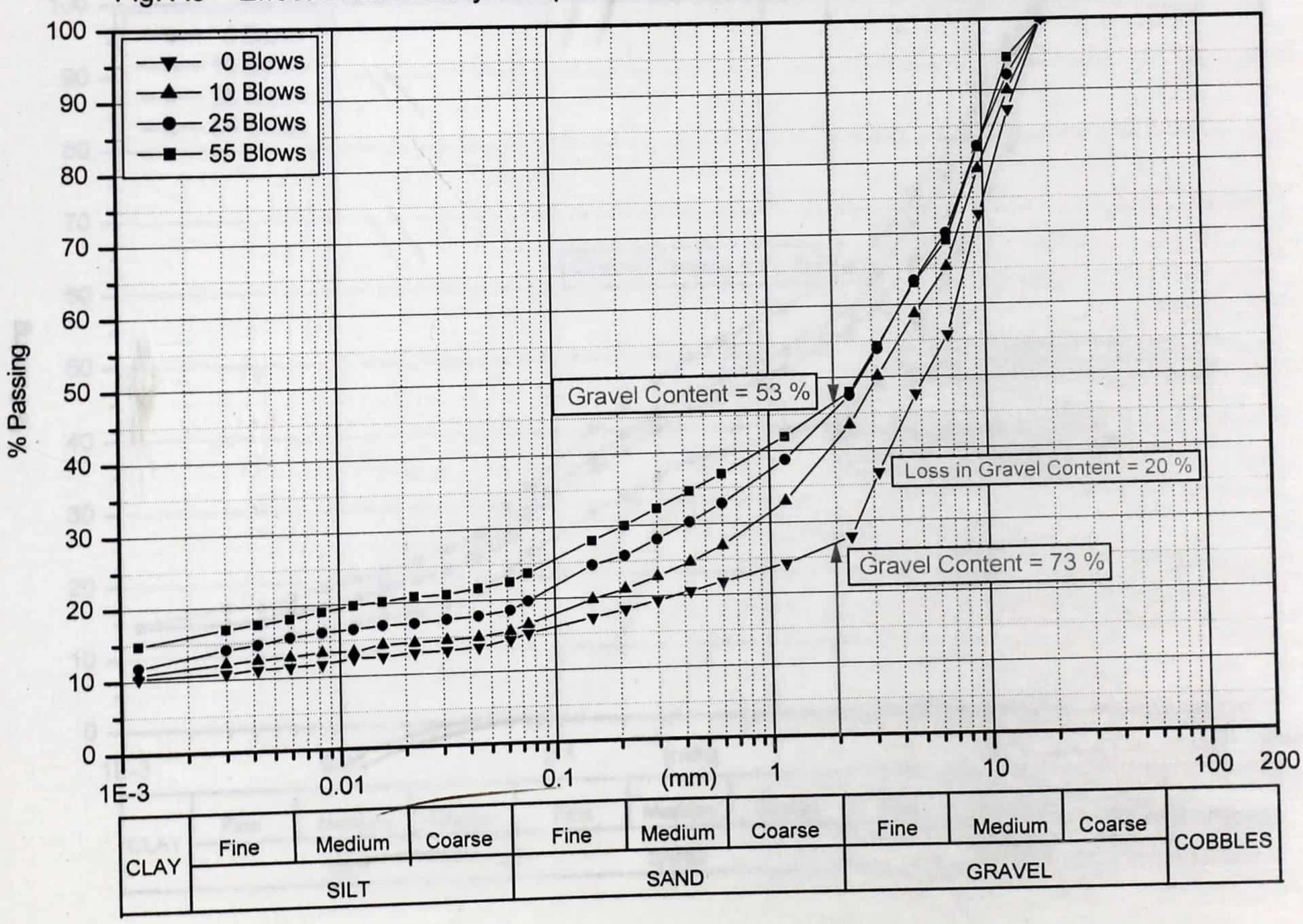
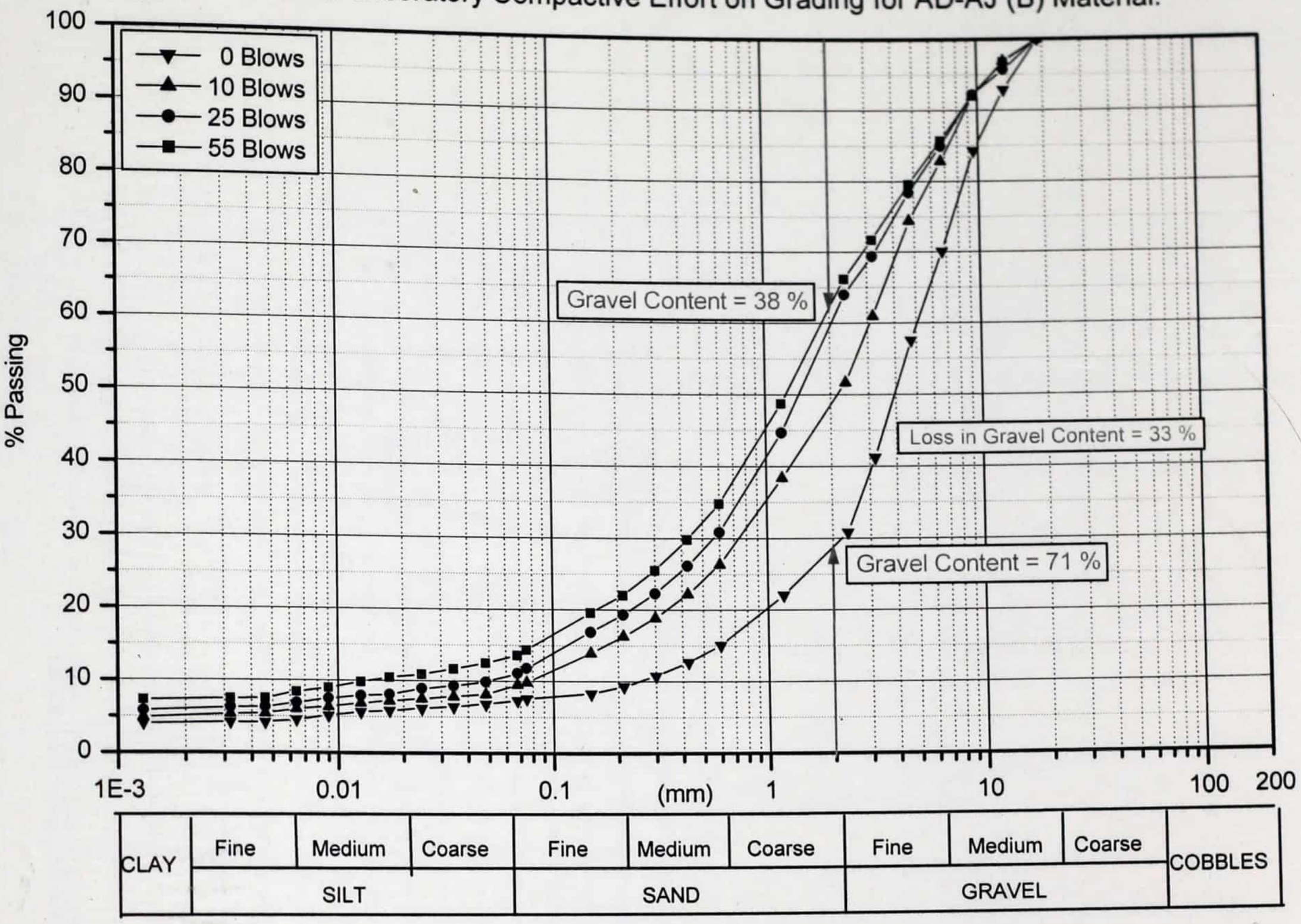
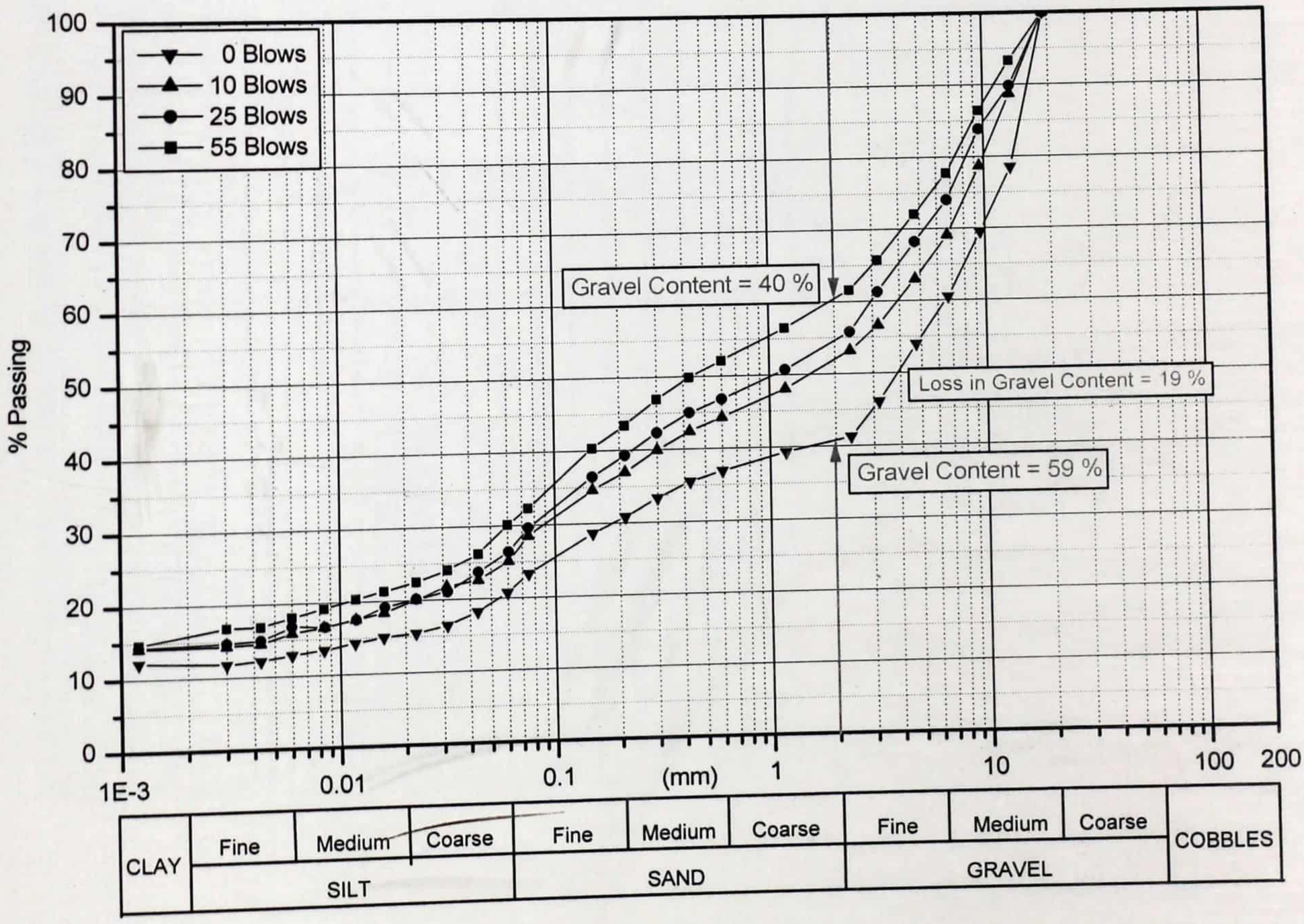


Fig. A9 Effect of Laboratory Compactive Effort on Grading for AD-AJ (B) Material.



APPENDIX B

Fig. A10 Effect of Laboratory Compactive Effort on Grading for K-W (SB) Material.



APPENDIX B

Table B10 COMPACTION TEST RESULTS- MODIFIED AASHTO

SOURCE OF MATERIAL : MABANG BORROW PIT STOCKPLIE FOR MODEL SITE COMPACTION STUDIES

Sample preparation	1	2	3	4	5
Mass of cylinder + Wet sample (gm)	9007	9342	9498	9428	9341
Mass of cylinder (gm)	4715	4715	4715	4715	4715
Mass of wet sample (gm)	4292	4627	4783	4713	4626
Bulk density (Mg/m^3)	2.054	2.214	2.289	2.256	2.214

Water Content Determination

Test No.	1	2	3	4	5
Container No.					
Mass of container+Wet soil (gm)	336.20	360.50	348.30	328.50	342.70
Mass of container+Dry soil (gm)	318.00	336.00	320.50	297.00	305.50
Mass of container (gm)	64.00	68.00	63.50	64.00	64.00
Mass of water (gm)	18.20	24.50	27.80	31.50	37.20
Mass of dry soil (gm)	254.00	268.00	257.00	233.00	241.50
Water content (%)	7.17	9.14	10.82	13.52	15.40
Average water content	7.17	9.14	10.82	13.52	15.40
Dry density (Mg/m^3)	1.917	2.029	2.066	1.987	1.918

Mould characteristics

Height of Mould (cm)	11.5
Diameter of mould (cm)	15.21
Volume of Mould (cc)	2090

Number of Roller Passes	2	4	6	8	10	12
Layer Compacted Thickness (cm)	12	12	12	11.9	11.9	11.4
A. Wt. of wet soil sample from hole (gm)	3994.5	4050.8	4074.5	4105.3	4189	4063.5
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	1587.7	1570.6	1592.5	1613	1607.8	1724.5
D. Wt. of sand in (hole + cone) (gm)	4412.3	4429.4	4407.5	4387	4392.2	4275.5
E. Wt. of sand in cone (gm)	1514	1514	1514	1514	1514	1514
F. Wt. of sand in hole (gm)	2898.3	2915.4	2893.5	2873	2878.2	2761.5
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	1.89	1.90	1.93	1.96	1.99	2.02
I. Moisture Content of soil (Speedy tester (%))	10.4	10.4	10.4	10.4	10.4	10.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.71	1.72	1.75	1.77	1.81	1.83
K. Laboratory Maximum dry density.	2.066	2.066	2.066	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	82.8	83.5	84.6	85.8	87.4	88.4

Table: B11 b Field density test (Loose layer thickness = 170mm & Roller weight = 825kg).

Number of Roller Passes	2	4	6	8	10	12
Layer Compacted Thickness (cm)	15	15	15	15	15	15
A. Wt. of wet soil sample from hole (gm)	4599	4691	4956.5	4989	4997.5	5018.5
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	936	983	860	873	893	906
D. Wt. of sand in (hole + cone) (gm)	5064	5017	5140	5127	5107	5094
E. Wt. of sand in cone (gm)	1514	1514	1514	1514	1514	1514
F. Wt. of sand in hole (gm)	3550	3503	3626	3613	3593	3580
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	1.77	1.83	1.87	1.89	1.91	1.92
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.62	1.68	1.71	1.73	1.74	1.76
K. Laboratory Maximum dry density.	2.066	2.066	2.066	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	78.5	81.2	82.9	83.7	84.3	85.0

Table: B11 c Field density test (Loose layer thickness = 220mm & Roller weight = 825kg).

Number of Roller Passes	2	4	6	8	10	12
Layer Compacted Thickness (cm)	15	15	15	15	15	15
A. Wt. of wet soil sample from hole (gm)	4518.2	4460.5	4539	4479.5	4521.5	4549
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	940.5	1003.5	958	1013.5	988.5	998.1
D. Wt. of sand in (hole + cone) (gm)	5059.5	4996.5	5042	4986.5	5011.5	5001.9
E. Wt. of sand in cone (gm)	1514	1514	1514	1514	1514	1514
F. Wt. of sand in hole (gm)	3545.5	3482.5	3528	3472.5	3497.5	3487.9
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	1.75	1.75	1.76	1.77	1.77	1.79
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.60	1.60	1.61	1.62	1.62	1.63
K. Laboratory Maximum dry density.	2.066	2.066	2.066	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	77.2	77.6	78.0	78.2	78.4	79.1

Table: B12 a Field density test (layer thickness = 120mm & roller weight = [illegible])

Number of Roller Passes	2	4	6	8	10	12
Layer Compacted Thickness (cm)	11.7	11.6	11.3	11.2	11.2	11.2
A. Wt. of wet soil sample from hole (gm)	2722.5	2739.4	2709.5	2718.5	2740.4	2755.2
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	2671	2691.5	2737.5	2746.5	2750	2756.7
D. Wt. of sand in (hole + cone) (gm) = B-C	3329	3308.5	3262.5	3253.5	3250	3243.3
E. Wt. of sand in cone (gm)	1514	1514	1514	1514	1514	1514
F. Wt. of sand in hole (gm) = D-E	1815	1794.5	1748.5	1739.5	1736	1729.3
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	2.06	2.09	2.12	2.14	2.16	2.18
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.88	1.91	1.94	1.96	1.98	2.00
K. Laboratory Maximum dry density.	2.066	2.066	2.066	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	90.9	92.5	93.9	94.7	95.7	96.6

Table: B12 b Field density test (Loose layer thickness = 170mm & Roller weight = 8,559kg).

Number of Roller Passes	2	4	6	8	10	12
Layer Compacted Thickness (cm)	15	15	15	15	15	15
A. Wt. of wet soil sample from hole (gm)	4511.1	4683.5	4738	4745.5	4767	4786.6
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	1037.6	1046	1051.6	1068.1	1083.1	1093.4
D. Wt. of sand in (hole + cone) (gm)	4962.4	4954	4948.4	4931.9	4916.9	4906.6
E. Wt. of sand in cone (gm)	1514	1514	1514	1514	1514	1514
F. Wt. of sand in hole (gm)	3448.4	3440	3434.4	3417.9	3402.9	3392.6
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	1.79	1.87	1.89	1.90	1.92	1.93
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.64	1.70	1.73	1.74	1.75	1.77
K. Laboratory Maximum dry density.	2.066	2.066	2.066	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	79.3	82.5	83.6	84.2	84.9	85.5

Table: B12 c Field density test (Loose layer thickness = 220mm & Roller weight of 8,559kg).

Number of Roller Passes	2	4	6	8	10	12
Layer Compacted Thickness (cm)	15	15	15	15	15	15
A. Wt. of wet soil sample from hole (gm)	4189.8	4204.5	4247.3	4351.5	4377.9	4367.6
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	1224	1236	1242.5	1257.5	1297.5	1348.7
D. Wt. of sand in (hole + cone) (gm)	4776	4764	4757.5	4742.5	4702.5	4651.3
E. Wt. of sand in cone (gm)	1514	1514	1514	1514	1514	1514
F. Wt. of sand in hole (gm)	3262	3250	3243.5	3228.5	3188.5	3137.3
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	1.76	1.77	1.79	1.85	1.88	1.91
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.61	1.62	1.64	1.69	1.72	1.74
K. Laboratory Maximum dry density.	2.066	2.066	2.066	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	77.9	78.4	79.4	81.7	83.2	84.4

Table: B13 a Field density test (

Number of Roller Passes	2	4	6
Layer Compacted Thickness (cm)	11.9	11.5	10
A. Wt. of wet soil sample from hole (gm)	2809.8	2818.3	2829.5
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	2636	2705.5	2939.5
D. Wt. of sand in (hole + cone) (gm)	3364	3294.5	3060.5
E. Wt. of sand in cone (gm)	1514	1514	1514
F. Wt. of sand in hole (gm)	1850	1780.5	1546.5
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	2.08	2.17	2.51
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.90	1.98	2.29
K. Laboratory Maximum dry density.	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	92.1	95.9	110.9

Table: B13 b Field density test (Loose layer thickness = 170mm & Roller weight = 15,380kg).

Number of Roller Passes	2	4	6	8	10	12
Layer Compacted Thickness (cm)	15	15	15	15	15	15
A. Wt. of wet soil sample from hole (gm)	4780	4895	4981.5	5074	5076.5	5139.7
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	887.5	912.5	956	955.4	1009.8	1018.4
D. Wt. of sand in (hole + cone) (gm)	5112.5	5087.5	5044	5044.6	4990.2	4981.6
E. Wt. of sand in cone (gm)	1514	1514	1514	1514	1514	1514
F. Wt. of sand in hole (gm)	3598.5	3573.5	3530	3530.6	3476.2	3467.6
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	1.82	1.88	1.93	1.97	2.00	2.03
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.66	1.72	1.77	1.80	1.83	1.86
K. Laboratory Maximum dry density.	2.066	2.066	2.066	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	80.5	83.0	85.5	87.1	88.5	89.8

Table: B13 c Field density test (Loose layer thickness = 220mm & Roller weight = 15,380kg).

Number of Roller Passes	2	4	6	8	10	12
Layer Compacted Thickness (cm)	15	15	15	15	15	15
A. Wt. of wet soil sample from hole (gm)	4652.4	4795	4871.5	4897.9	4969.5	5013.7
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	907.5	889.7	914.6	982.4	989	1000
D. Wt. of sand in (hole + cone) (gm)	5092.5	5110.3	5085.4	5017.6	5011	5000
E. Wt. of sand in cone (gm)	1514	1514	1514	1514	1514	1514
F. Wt. of sand in hole (gm)	3578.5	3596.3	3571.4	3503.6	3497	3486
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	1.78	1.83	1.87	1.92	1.95	1.97
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	1.63	1.67	1.71	1.75	1.78	1.80
K. Laboratory Maximum dry density.	2.066	2.066	2.066	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	78.8	80.8	82.7	84.7	86.1	87.2

Table: B14 a DCP Test Results for Model Site Compaction Studies

SITE: Model Construction Site. DATE: 30:05:01

PAVEMENT
THICKNESS: 120mm loose
ROLLER WEIGHT: 825 kg.

DCP TEST DATA

No. of passes = 2				No. of passes = 4				No. of passes = 6			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	56	0	0	0	46	0	0	0	52	0
5	5	77	21	5	5	67	21	5	5	73	21
5	10	98	42	5	10	87	41	5	10	93	41
5	15	129	73	5	15	115	69	5	15	121	69
5	20	162	106	5	20	146	100	5	20	152	100
5	25	182	126	5	25	168	122	5	25	171	119
5	30	196	140	5	30	181	135	5	30	183	131

No. of passes = 8				No. of passes = 10				No. of passes = 12			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	39	0	0	0	51	0	0	0	43	0
5	5	59	20	5	5	70	19	5	5	61	18
5	10	78	39	5	10	89	38	5	10	80	37
5	15	104	65	5	15	111	60	5	15	100	57
5	20	134	95	5	20	140	89	5	20	129	86
5	25	154	115	5	25	161	110	5	25	150	107
5	30	166	127	5	30	173	122	5	30	160	117

Table: B14 b DCP Test Results for Model Site Compaction Studies

SITE: Model Construction Site. DATE: 29:05:01

PAVEMENT
THICKNESS: 170mm loose
ROLLER WEIGHT: 825 kg.

DCP TEST DATA

No. of passes = 2				No. of passes = 4				No. of passes = 6			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	54	0	0	0	52	0	0	0	56	0
5	5	78	24	5	5	73	21	5	5	77	21
5	10	117	63	5	10	105	53	5	10	98	42
5	15	156	102	5	15	142	90	5	15	141	85
5	20	195	141	5	20	176	124	5	20	174	118
5	25	232	178	5	25	213	161	5	25	210	154
5	30	240	186	5	30	226	174	5	30	231	175
5	35	256	202	5	35	240	188	5	35	244	188
5	40	271	217	5	40	253	201	5	40	258	202

No. of passes = 8				No. of passes = 10				No. of passes = 12			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	40	0	0	0	50	0	0	0	60	0
5	5	61	21	5	5	71	21	5	5	80	20
5	10	82	42	5	10	91	41	5	10	100	40
5	15	120	80	5	15	125	75	5	15	135	75
5	20	154	114	5	20	157	107	5	20	166	106
5	25	188	148	5	25	190	140	5	25	199	139
5	30	206	166	5	30	211	161	5	30	220	160
5	35	219	179	5	35	225	175	5	35	233	173
5	40	233	193	5	40	238	188	5	40	246	186

Table: B14 c DCP Test Results for Model Site Compaction Studies

SITE: Model Construction Site. DATE: 28:05:01

PAVEMENT
THICKNESS: 220mm loose
ROLLER WEIGHT: 825 kg.

DCP TEST DATA

No. of passes = 2				No. of passes = 4				No. of passes = 6			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	51	0	0	0	41	0	0	0	53	0
5	5	76	25	5	5	67	26	5	5	78	25
5	10	102	51	5	10	92	51	5	10	102	49
5	15	149	98	5	15	140	99	5	15	147	94
5	20	192	141	5	20	182	141	5	20	185	132
5	25	233	182	5	25	224	183	5	25	223	170
5	30	274	223	5	30	265	224	5	30	261	208
5	35	288	237	5	35	278	237	5	35	282	229
5	40	305	254	5	40	294	253	5	40	298	245

No. of passes = 8				No. of passes = 10				No. of passes = 12			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	46	0	0	0	44	0	0	0	42	0
5	5	70	24	5	5	68	24	5	5	66	24
5	10	95	49	5	10	92	48	5	10	89	47
5	15	139	93	5	15	132	88	5	15	131	89
5	20	178	132	5	20	170	126	5	20	169	127
5	25	216	170	5	25	206	162	5	25	205	163
5	30	254	208	5	30	244	200	5	30	242	200
5	35	275	229	5	35	268	224	5	35	265	223
5	40	291	245	5	40	291	247	5	40	280	238
								5	45	295	253

Table: B15 a DCP Test Results for Model Site Compaction Studies

SITE: Model Construction Site. DATE: 28:05:01

PAVEMENT
THICKNESS: 120mm loose
ROLLER WEIGHT: 8,559 kg.

DCP TEST DATA

No. of passes = 2				No. of passes = 4				No. of passes = 6			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	30	0	0	0	37	0	0	0	30	0
5	5	47	17	5	5	53	16	5	5	45	15
5	10	63	33	5	10	69	32	5	10	63	33
5	15	85	55	5	15	90	53	5	15	85	55
5	20	110	80	5	20	114	77	5	20	110	80
5	25	135	105	5	25	139	102	5	25	136	106
5	30	152	122	5	30	154	117	5	30	149	119
5	35	162	132	5	35	164	127	5	35	159	129

No. of passes = 8				No. of passes = 10				No. of passes = 12			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	30	0	0	0	29	0	0	0	25	0
5	5	46	16	5	5	45	16	5	5	40	15
5	10	61	31	5	10	60	31	5	10	55	30
5	15	82	52	5	15	81	52	5	15	70	45
5	20	106	76	5	20	105	76	5	20	95	70
5	25	130	100	5	25	129	100	5	25	117	92
5	30	145	115	5	30	141	112	5	30	132	107
5	35	155	125	5	35	151	122	5	35	150	125
								5	40	159	134

Table: B15 b DCP Test Results for Model Site Compaction Studies

SITE: Model Construction Site. DATE: 27:05:01

PAVEMENT
THICKNESS: 170mm loose
ROLLER WEIGHT: 8,559 kg.

DCP TEST DATA

No. of passes = 2				No. of passes = 4				No. of passes = 6			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	132	0	0	0	112	0	0	0	105	0
5	5	156	24	5	5	135	23	5	5	126	21
5	10	179	47	5	10	157	45	5	10	147	42
5	15	230	98	5	15	202	90	5	15	189	84
5	20	267	135	5	20	237	125	5	20	222	117
5	25	305	173	5	25	271	159	5	25	254	149
5	30	316	184	5	30	289	177	5	30	277	172
5	35	331	199	5	35	304	192	5	35	291	186
				5	40	318	206	5	40	305	200

No. of passes = 8				No. of passes = 10				No. of passes = 12			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	105	0	0	0	101	0	0	0	105	0
5	5	126	21	5	5	121	20	5	5	126	21
5	10	146	41	5	10	142	41	5	10	144	39
5	15	185	80	5	15	183	82	5	15	180	75
5	20	218	113	5	20	214	113	5	20	209	104
5	25	249	144	5	25	246	145	5	25	238	133
5	30	271	166	5	30	265	164	5	30	268	163
5	35	281	176	5	35	278	177	5	35	275	170
5	40	296	191	5	40	292	191	5	40	286	181

Table: B15 c DCP Test Results for Model Site Compaction Studies

SITE: Model Construction Site.	DATE: 27:05:01
PAVEMENT THICKNESS: 220mm loose	
ROLLER WEIGHT: 8,559 kg.	

No. of passes = 2			
No. Blows	Total Blows	Reading mm	
0	0	105	0
5	5	130	25
5	10	154	49
5	15	199	94
5	20	238	133
5	25	280	175
5	30	316	211
5	35	326	221
5	40	332	227

No. of passes = 4			
No. Blows	Total Blows	Reading mm	
0	0	105	0
5	5	129	24
5	10	153	48
5	15	198	93
5	20	237	132
5	25	275	170
5	30	314	209
5	35	334	229
5	40	350	245

No. of passes = 6			
No. Blows	Total Blows	Reading mm	
0	0	102	0
5	5	125	23
5	10	149	47
5	15	197	95
5	20	240	138
5	25	280	178
5	30	322	220
5	35	326	224
5	40	331	229

No. of passes = 8			
No. Blows	Total Blows	Reading mm	
0	0	105	0
5	5	128	23
5	10	150	45
5	15	189	84
5	20	225	120
5	25	260	155
5	30	296	191
5	35	320	215
5	40	335	230

No. of passes = 10			
No. Blows	Total Blows	Reading mm	
0	0	100	0
5	5	121	21
5	10	142	42
5	15	176	76
5	20	210	110
5	25	244	144
5	30	278	178
5	35	309	209
5	40	323	223

No. of passes = 12			
No. Blows	Total Blows	Reading mm	
0	0	93	0
5	5	113	20
5	10	134	41
5	15	163	70
5	20	193	100
5	25	225	132
5	30	256	163
5	35	287	194
5	40	306	213
5	45	319	226

ble: B16 a DCP Test Results for Model Site Compaction Studies

TE: Model Construction Site.

DATE: 26:05:01

VEMENT
ICKNESS: 120mm loose
OLLER WEIGHT: 15,380 kg.

DCP TEST DATA

No. of passes = 2				No. of passes = 4				No. of passes = 6			
No. lows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	106	0	0	0	103	0	0	0	100	0
5	5	121	15	5	5	118	15	5	5	113	13
5	10	137	31	5	10	132	29	5	10	126	26
5	15	153	47	5	15	149	46	5	15	140	40
5	20	168	62	5	20	162	59	5	20	153	53
5	25	186	80	5	25	177	74	5	25	167	67
5	30	226	120	5	30	193	90	5	30	182	82
5	35	229	123	5	35	207	104	5	35	193	93
5	40	243	137	5	40	218	115	5	40	203	103
				5	45	221	118	5	45	207	107
				5	50	227	124	5	50	212	112

Table: B16 b DCP Test Results for Model Site Compaction Studies

SITE: Model Construction Site.

DATE: 26:05:01

PAVEMENT
THICKNESS: 170mm loose
ROLLER WEIGHT: 15,380 kg.

DCP TEST DATA

No. of passes = 2				No. of passes = 4				No. of passes = 6			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	100	0	0	0	110	0	0	0	110	0
5	5	121	21	5	5	131	21	5	5	130	20
5	10	144	44	5	10	152	42	5	10	150	40
5	15	166	66	5	15	173	63	5	15	170	60
5	20	199	99	5	20	201	91	5	20	194	84
5	25	233	133	5	25	233	123	5	25	227	117
5	30	267	167	5	30	267	157	5	30	260	150
5	35	279	179	5	35	285	175	5	35	286	176
5	40	292	192	5	40	298	188	5	40	300	190
5	45	304	204	5	45	312	202	5	45	314	204

No. of passes = 8				No. of passes = 10				No. of passes = 12			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	111	0	0	0	107	0	0	0	115	0
5	5	130	19	5	5	125	18	5	5	132	17
5	10	149	38	5	10	143	36	5	10	148	33
5	15	169	58	5	15	161	54	5	15	165	50
5	20	187	76	5	20	179	72	5	20	181	66
5	25	220	109	5	25	208	101	5	25	198	83
5	30	253	142	5	30	242	135	5	30	218	103
5	35	283	172	5	35	268	161	5	35	251	136
5	40	297	186	5	40	282	175	5	40	272	157
5	45	311	200	5	45	296	189	5	45	285	170

ie: B16 c DCP Test Results for Model Site Compaction Studies

E: Model Construction Site.

DATE: 26.05.01

VEMENT

CKNESS: 220mm loose

LLER WEIGHT: 15,380 kg.

DCP TEST DATA

No. of passes = 2				No. of passes = 4				No. of passes = 6			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	105	0	0	0	110	0	0	0	110	0
5	5	128	23	5	5	132	22	5	5	131	21
5	10	153	48	5	10	154	44	5	10	152	42
5	15	176	71	5	15	177	67	5	15	173	63
5	20	228	123	5	20	220	110	5	20	211	101
5	25	266	161	5	25	256	146	5	25	244	134
5	30	305	200	5	30	290	180	5	30	277	167
5	35	330	225	5	35	326	216	5	35	310	200
5	40	343	238	5	40	339	229	5	40	333	223
5	45	356	251	5	45	353	243	5	45	346	236
								5	50	360	250

No. of passes = 8				No. of passes = 10				No. of passes = 12			
No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm		No. Blows	Total Blows	Reading mm	
0	0	108	0	0	0	105	0	0	0	100	0
5	5	129	21	5	5	125	20	5	5	119	19
5	10	149	41	5	10	145	40	5	10	138	38
5	15	170	62	5	15	166	61	5	15	158	58
5	20	201	93	5	20	192	87	5	20	181	81
5	25	233	125	5	25	225	120	5	25	212	112
5	30	265	157	5	30	257	152	5	30	243	143
5	35	297	189	5	35	288	183	5	35	275	175
5	40	321	213	5	40	320	215	5	40	306	206
5	45	335	227	5	45	335	230	5	45	326	226
				5	45	347	242	5	45	338	238

Fig. B.1 Particle Size Distribution for the Number of Passes of an 825 kg Duplex Vibratory Roller (On a 170 mm loose bed thickness).

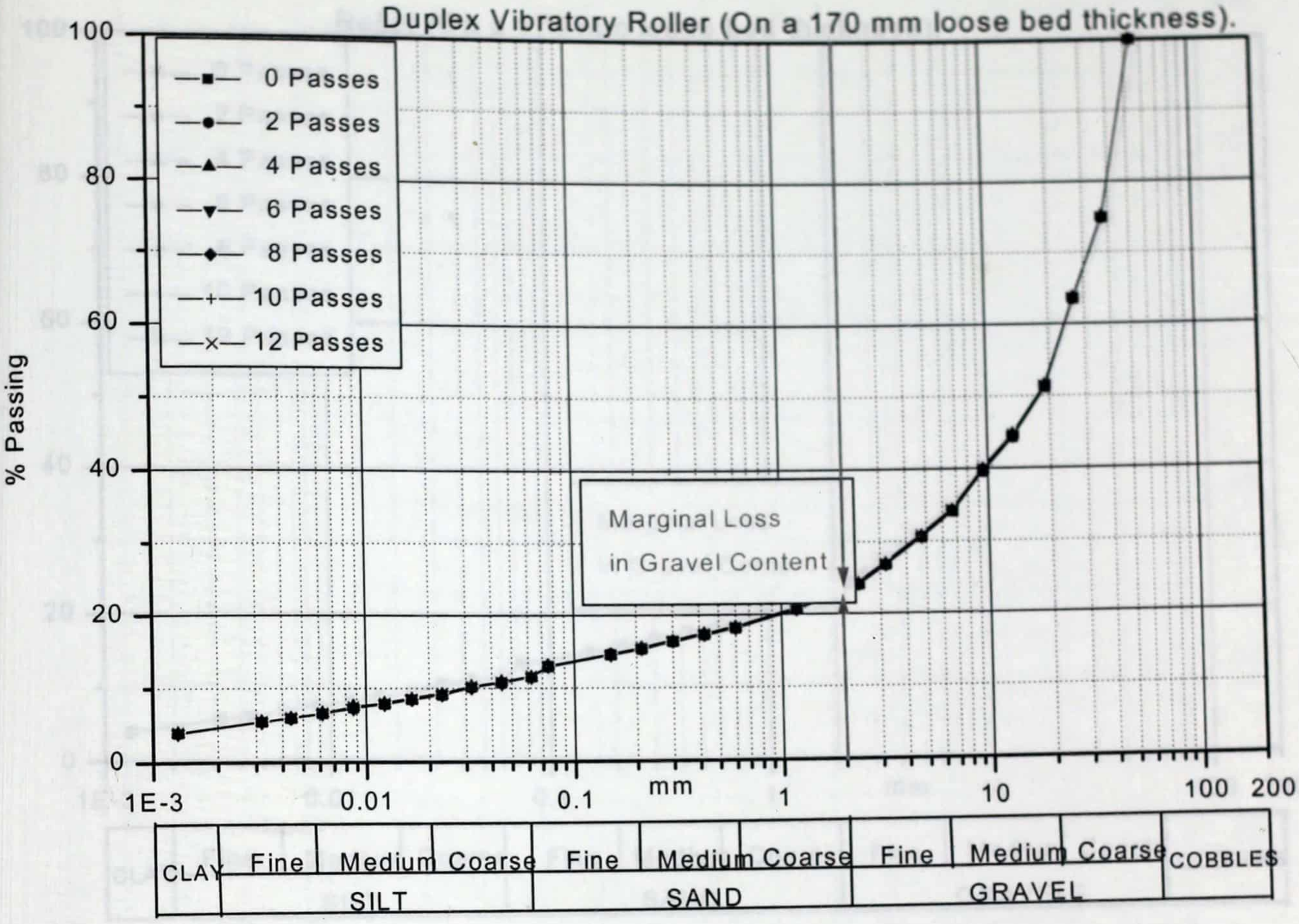


Fig. B.2 Particle Size Distribution for Number of Passes of an 825 kg Duplex Vibratory Roller (On a 220 mm loose bed thickness).

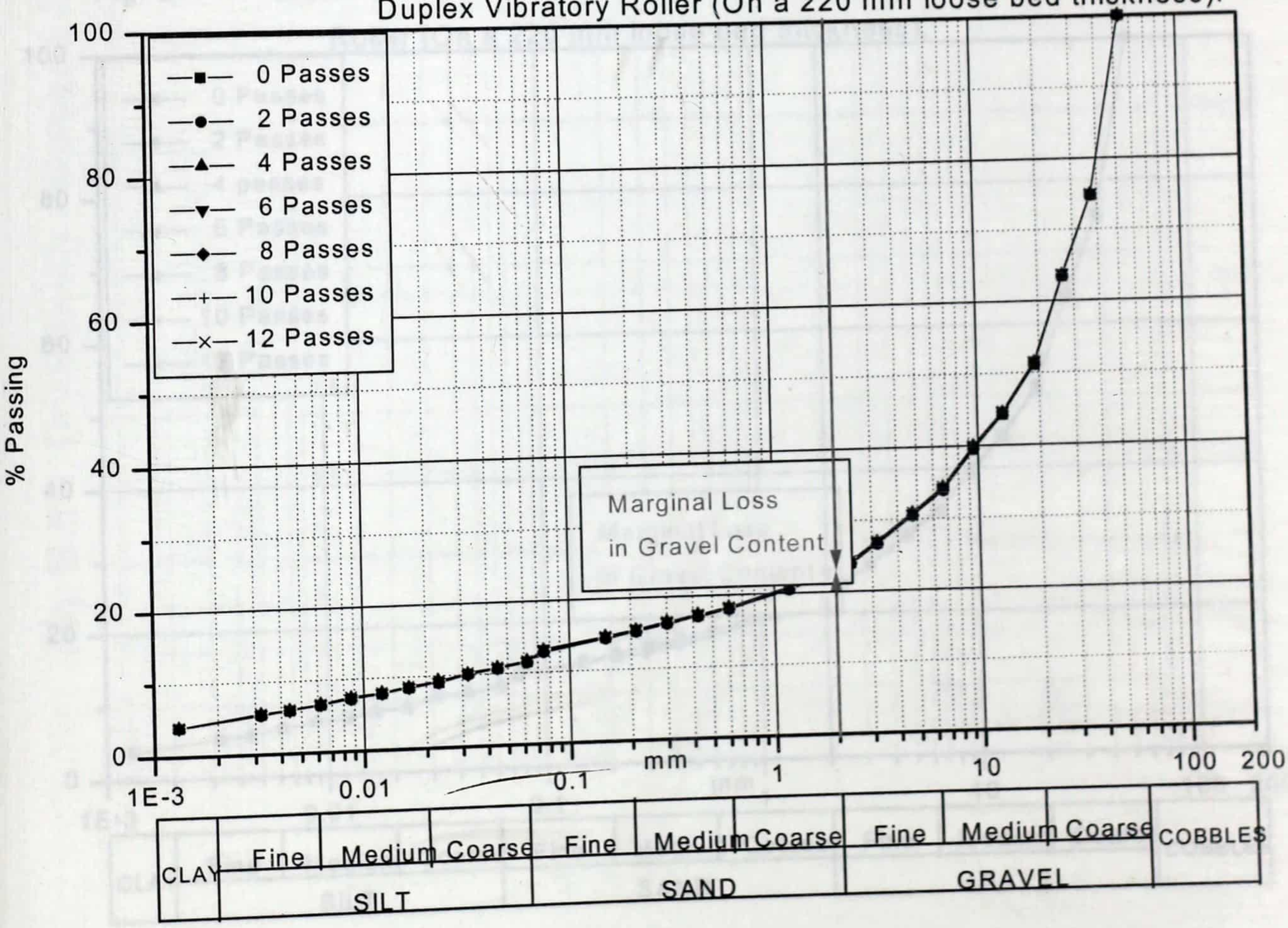


Fig. B.3 Particle Size Distribution for Number of Passes of an 8,559 kg Static Roller (On a 170 mm loose bed thickness)

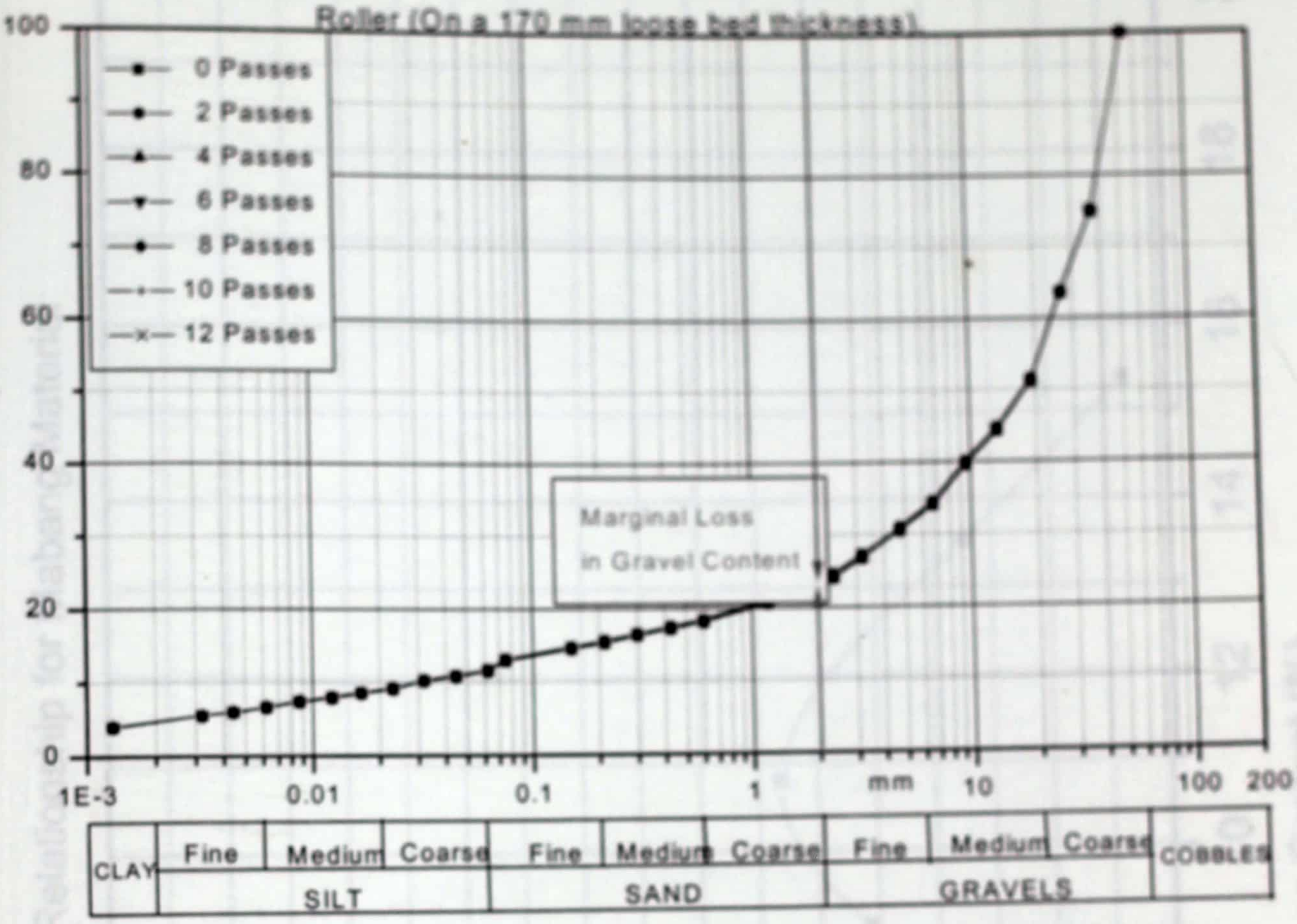


Fig. B.4 Particle Size Distribution for Number of Passes of an 8,559 kg Static Roller (On a 220 mm loose bed thickness).

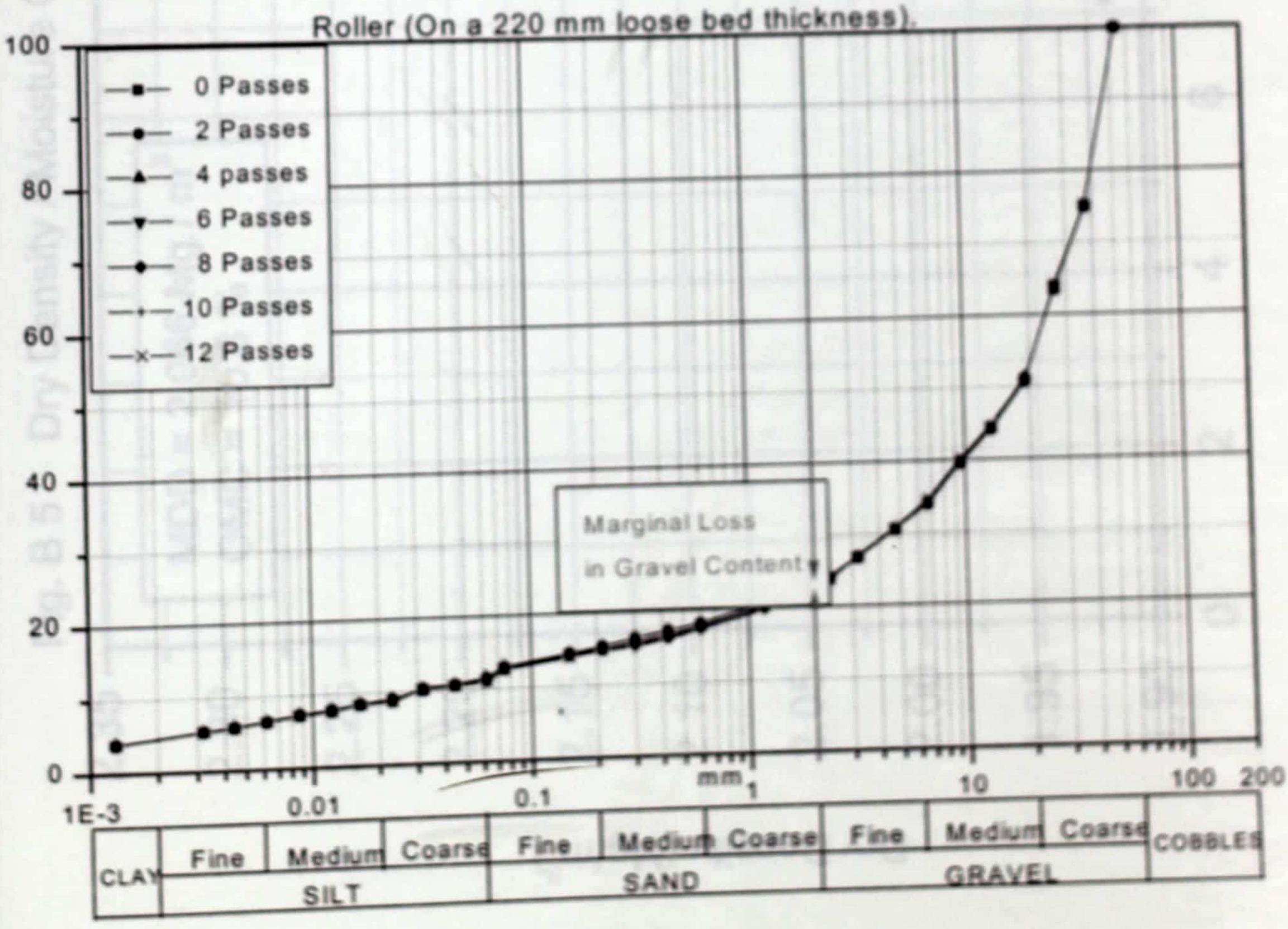
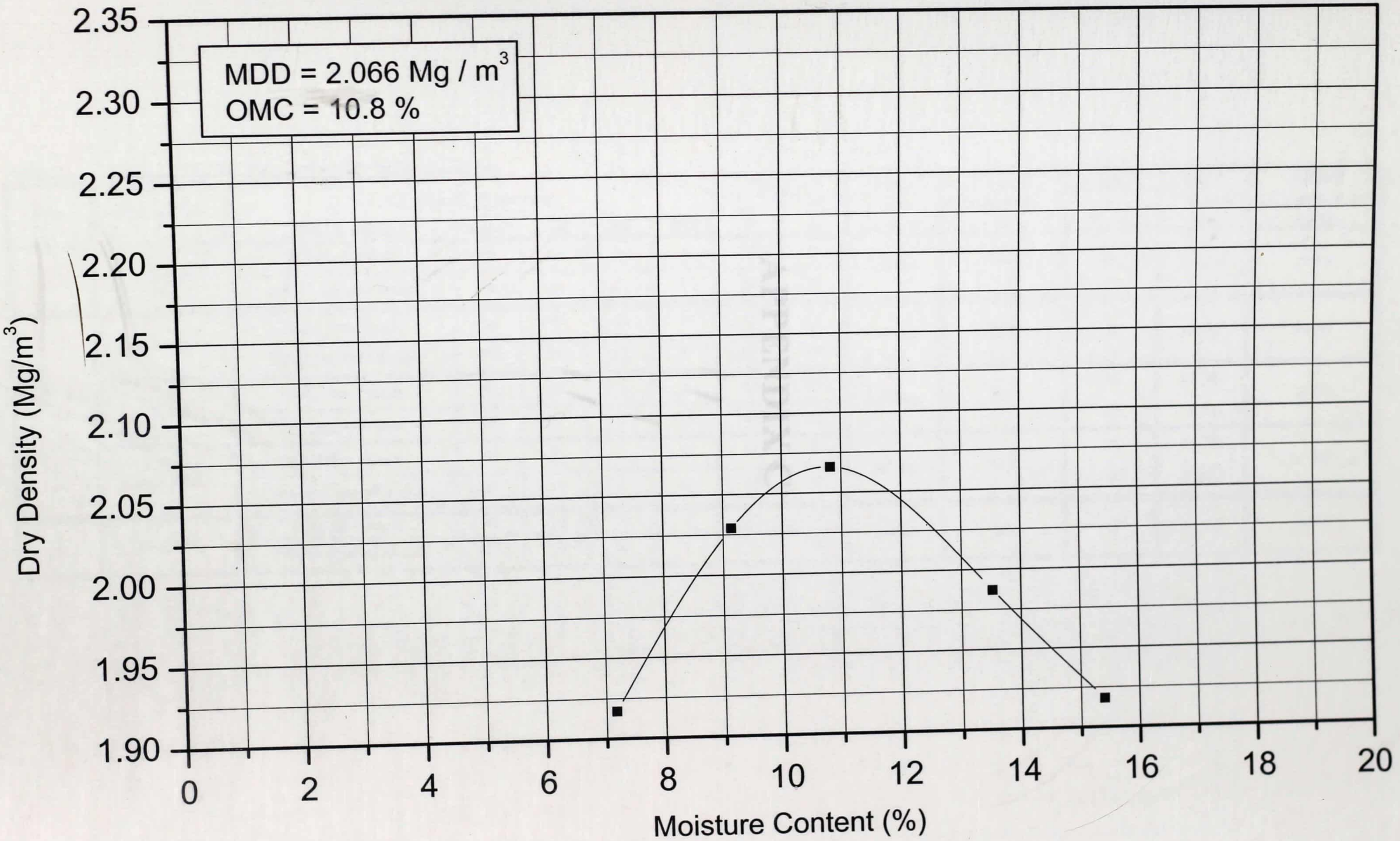


Fig. B 5 Dry Density / Moisture Content Relationship for Mabang Material



APPENDIX C

Table C1 Summary of Results of Construction Site Compaction Studies

Zone	Project Code	Grading (% Proportion)					Plasticity		Loose layer thickness	Level of Compaction %	No. of Passes	Roller Weight Kg	AASHTO Classification System
		Soil Condition	Gravel	Sand	Silt	Clay	LL %	PI %					
1	T-K (SB)	Field Raw Sample	79	14	4	4	35	12	180cm	93	40	17,500	A-2-6
		Field Compacted Sample	64	24	9	4	32	11					
2	JZ-Y (SB)	Field Raw Sample	70	14	10	7	31	15	180cm	98.7	35	11,400	A-2-6
		Field Compacted Sample	57	24	10	8	29	14					
	GR (B)	Field Raw Sample	72	17	7	4	33	15	200cm	101	36	15,380	A-2-6
		Field Compacted Sample	61	19	8	11	42	25			36	11,559	
	A-N (SB)	Field Raw Sample	85	8	4	3	40	19	200cm	98.8	30	15,250	A-2-7
		Field Compacted Sample	62	22	6	10	46	25			30	14,515	
3	AJ-AD (B)	Field Raw Sample	62	29	4	6	32	17	180cm	102	42	14,500	A-2-6
		Field Compacted Sample	55	36	4	5	32	16					

Table C2 (a) GRADING OF THE FIELD RAW SAMPLE FOR T-K (SB)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing (%)
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			100.0
1 in	26.50	50.7	5.1	94.9
$^3/_4$ in	19.00	38.9	3.9	91.0
$^1/_2$ in	13.20	192.4	19.2	71.8
$^3/_8$ in	9.50	139.4	13.9	57.9
$^1/_4$ in	6.70	130.2	13.0	44.8
$^3/_{16}$ in	4.75	91.4	9.1	35.7
$^1/_8$ in	3.18	90.4	9.0	26.7
No. 7	2.36	42.0	4.2	22.5
No. 14	1.18	10.8	4.9	17.6
No. 25	0.600	5.5	2.5	15.1
No. 36	0.425	1.9	0.8	14.3
No. 52	0.300	1.6	0.7	13.6
No. 72	0.212	1.6	0.7	12.9
No. 100	0.150	1.7	0.7	12.1
No. 200	0.075	5.1	2.3	9.8
Passing No. 200				
Total		733.4		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight 50g Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	24.0	0.5	1.0140	14.0	14.5	143.33	0.909	0.0658	0.8069	11.21	7.92
	24.0	1.0	1.0130	13.0	13.5	147.28	0.909	0.0472	0.8069	10.21	7.22
	24.0	2.0	1.0122	12.2	12.7	150.44	0.909	0.0337	0.8069	9.41	6.65
	24.0	4.0	1.0114	11.4	11.9	153.60	0.91	0.0241	0.8069	8.61	6.09
	24.0	8.0	1.0110	11.0	11.5	155.18	0.91	0.0171	0.8069	8.21	5.80
	24.0	15.0	1.0105	10.5	11.0	157.15	0.91	0.0126	0.8069	7.71	5.45
	24.0	30.0	1.0102	10.2	10.7	158.34	0.91	0.0089	0.8069	7.41	5.24
	24.0	60.0	1.0096	9.6	10.1	160.71	0.91	0.0064	0.8069	6.81	4.81
	24.0	120	1.0089	8.9	9.4	163.47	0.91	0.0045	0.8069	6.11	4.32
	24.0	240	1.0086	8.6	9.1	164.66	0.91	0.0032	0.8069	5.81	4.11
	24.0	1440	1.0076	7.6	8.1	168.61	0.91	0.0013	0.8069	4.81	3.40

Table C2 (b) GRADING OF THE FIELD COMPACTED SAMPLE FOR T-K (SB)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing (%)
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			
$1^1/_2$ in	37.10			
1 in	26.50			100.0
$^3/_4$ in	19.00	55.9	5.6	94.4
$^1/_2$ in	13.20	55.2	5.5	88.9
$^3/_8$ in	9.50	79.4	7.9	80.9
$^1/_4$ in	6.70	134.6	13.5	67.5
$^3/_{16}$ in	4.75	97.8	9.8	57.7
$^1/_8$ in	3.18	124.7	12.5	45.2
No. 7	2.36	74.5	7.4	37.8
No. 14	1.18	8.6	6.5	31.3
No. 25	0.600	5.8	4.4	26.9
No. 36	0.425	2.1	1.6	25.3
No. 52	0.300	1.9	1.4	23.8
No. 72	0.212	1.9	1.4	22.5
No. 100	0.150	1.9	1.4	21.0
No. 200	0.075	6.1	4.6	16.5
Passing No. 200				
Total		547.6		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	25.0	0.5	1.0130	13.0	13.5	147.28	0.888	0.0659	1.0358	10.44	12.40
	25.0	1.0	1.0115	11.5	12.0	153.20	0.888	0.0476	1.0358	8.94	10.62
	25.0	2.0	1.0110	11.0	11.5	155.18	0.888	0.0338	1.0358	8.44	10.02
	25.0	4.0	1.0100	10.0	10.5	159.13	0.89	0.0242	1.0358	7.44	8.83
	25.0	8.0	1.0090	9.0	9.5	163.08	0.89	0.0173	1.0358	6.44	7.65
	25.0	15.0	1.0087	8.7	9.2	164.26	0.89	0.0127	1.0358	6.14	7.29
	25.0	30.0	1.0080	8.0	8.5	167.03	0.89	0.0091	1.0358	5.44	6.46
	25.0	60.0	1.0077	7.7	8.2	168.21	0.89	0.0064	1.0358	5.14	6.10
	24.0	120	1.0075	7.5	8.0	169.00	0.91	0.0046	0.8069	4.71	5.59
	24.0	240	1.0064	6.4	6.9	173.35	0.91	0.0033	0.8069	3.61	4.28
	25.0	1440	1.0050	5.0	5.5	178.88	0.89	0.0014	1.0358	2.44	2.89

Table C3 (a) GRADING OF THE FIELD RAW SAMPLE FOR JZ-Y (SB)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 2000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing (%)
BS designation	Metric (mm)			
3 in	75.00			
$2^{1}/_{2}$ in	63.00			
2 in	53.00			100.0
$1^{1}/_{2}$ in	37.10	55.7	2.8	97.2
1 in	26.50	72.0	3.6	93.6
$^{3}/_{4}$ in	19.00	115.1	5.8	87.9
$^{1}/_{2}$ in	13.20	220.0	11.0	76.9
$^{3}/_{8}$ in	9.50	268.8	13.4	63.4
$^{1}/_{4}$ in	6.70	321.0	16.1	47.4
$^{3}/_{16}$ in	4.75	145.8	7.3	40.1
$^{1}/_{8}$ in	3.18	118.7	5.9	34.1
No. 7	2.36	50.4	2.5	31.6
No. 14	1.18	6.6	4.2	27.5
No. 25	0.600	3.2	2.0	25.4
No. 36	0.425	1.1	0.7	24.7
No. 52	0.300	1.4	0.9	23.9
No. 72	0.212	1.8	1.1	22.7
No. 100	0.150	1.4	0.9	21.8
No. 200	0.075	4.6	2.9	18.9
Passing No. 200				
Total		1317.1		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs= 2.75**

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	27.4	0.5	1.0185	18.5	19.0	125.55	0.839	0.0592	1.6292	16.53	16.42
	27.4	1.0	1.0170	17.0	17.5	131.48	0.839	0.0428	1.6292	15.03	14.93
	27.4	2.0	1.0155	15.5	16.0	137.40	0.839	0.0310	1.6292	13.53	13.44
	27.4	4.0	1.0145	14.5	15.0	141.35	0.84	0.0222	1.6292	12.53	12.44
	27.4	8.0	1.0136	13.6	14.1	144.91	0.84	0.0159	1.6292	11.63	11.55
	27.4	15.0	1.0129	12.9	13.4	147.67	0.84	0.0117	1.6292	10.93	10.85
	27.0	30.0	1.0120	12.0	12.5	151.23	0.85	0.0084	1.5260	9.93	9.86
	27.0	60.0	1.0110	11.0	11.5	155.18	0.85	0.0060	1.5260	8.93	8.86
	26.2	120	1.0104	10.4	10.9	157.55	0.86	0.0043	1.3248	8.12	8.07
	27.6	240	1.0096	9.6	10.1	160.71	0.84	0.0031	1.6814	7.68	7.63
	30.8	1440	1.0075	7.5	8.0	169.00	0.78	0.0012	2.5756	6.48	6.43

Table C3 (b) GRADING OF THE FIELD COMPACTED SAMPLE FOR JZ-Y (SB)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing (%)
BS designation	Metric (mm)			
3 in	75.00			
$2^{1}/_{2}$ in	63.00			
2 in	53.00			
$1^{1}/_{2}$ in	37.10			
1 in	26.50			100.0
$^{3}/_{4}$ in	19.00	24.8	1.7	98.3
$^{1}/_{2}$ in	13.20	75.7	5.0	93.3
$^{3}/_{8}$ in	9.50	143.9	9.6	83.7
$^{1}/_{4}$ in	6.70	220.3	14.7	69.0
$^{3}/_{16}$ in	4.75	144.6	9.6	59.4
$^{1}/_{8}$ in	3.18	151.0	10.1	49.3
No. 7	2.36	70.8	4.7	44.6
No. 14	1.18	8.8	7.8	36.7
No. 25	0.600	4.8	4.3	32.5
No. 36	0.425	1.6	1.4	31.0
No. 52	0.300	2.0	1.8	29.3
No. 72	0.212	2.3	2.1	27.2
No. 100	0.150	1.9	1.7	25.5
No. 200	0.075	4.8	4.3	21.2
Passing No. 200				
Total		760.3		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight 50g **Gs= 2.75**

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	27.4	0.5	1.0150	15.0	15.5	139.38	0.839	0.0624	1.6292	13.03	18.26
	27.4	1.0	1.0136	13.6	14.1	144.91	0.839	0.0450	1.6292	11.63	16.30
	27.4	2.0	1.0124	12.4	12.9	149.65	0.839	0.0323	1.6292	10.43	14.62
	27.4	4.0	1.0115	11.5	12.0	153.20	0.84	0.0231	1.6292	9.53	13.36
	27.4	8.0	1.0109	10.9	11.4	155.57	0.84	0.0165	1.6292	8.93	12.52
	27.4	15.0	1.0103	10.3	10.8	157.94	0.84	0.0121	1.6292	8.33	11.68
	27.0	30.0	1.0096	9.6	10.1	160.71	0.85	0.0087	1.5260	7.53	10.55
	27.0	60.0	1.0090	9.0	9.5	163.08	0.85	0.0062	1.5260	6.93	9.71
	26.2	120	1.0087	8.7	9.2	164.26	0.86	0.0044	1.3248	6.42	9.01
	27.6	240	1.0080	8.0	8.5	167.03	0.84	0.0031	1.6814	6.08	8.52
	30.8	1440	1.0060	6.0	6.5	174.93	0.78	0.0013	2.5756	4.98	6.97

Table C4 (a) GRADING OF THE FIELD RAW SAMPLE FOR GR (B)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 3000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing (%)
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			100.0
2 in	53.00	374.9	12.5	87.5
$1^1/_2$ in	37.10	183.3	6.1	81.4
1 in	26.50	417.2	13.9	67.5
$^3/_4$ in	19.00	175.6	5.9	61.6
$^1/_2$ in	13.20	152.3	5.1	56.6
$^3/_8$ in	9.50	113.3	3.8	52.8
$^1/_4$ in	6.70	155.3	5.2	47.6
$^3/_{16}$ in	4.75	138.8	4.6	43.0
$^1/_8$ in	3.18	256.4	8.5	34.4
No. 7	2.36	162.1	5.4	29.0
No. 14	1.18	10.9	6.3	22.7
No. 25	0.600	3.4	2.0	20.8
No. 36	0.425	1.2	0.7	20.1
No. 52	0.300	1.4	0.8	19.3
NO. 72	0.212	1.7	1.0	18.3
No. 100	0.150	1.8	1.0	17.2
No. 200	0.075	7.5	4.4	12.9
Passing No. 200				
Total		1967.1		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs=** 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	27.4	0.5	1.0140	14.0	14.5	143.33	0.839	0.0633	1.6292	12.03	10.96
	27.4	1.0	1.0110	11.0	11.5	155.18	0.839	0.0465	1.6292	9.03	8.23
	27.4	2.0	1.0095	9.5	10.0	161.10	0.839	0.0335	1.6292	7.53	6.86
	27.4	4.0	1.0085	8.5	9.0	165.05	0.84	0.0240	1.6292	6.53	5.95
	27.4	8.0	1.0082	8.2	8.7	166.24	0.84	0.0170	1.6292	6.23	5.68
	27.4	15.0	1.0077	7.7	8.2	168.21	0.84	0.0125	1.6292	5.73	5.22
	27.0	30.0	1.0070	7.0	7.5	170.98	0.85	0.0090	1.5260	4.93	4.49
	27.0	60.0	1.0064	6.4	6.9	173.35	0.85	0.0064	1.5260	4.33	3.94
	26.2	120	1.0060	6.0	6.5	174.93	0.86	0.0046	1.3248	3.72	3.39
	27.6	240	1.0058	5.8	6.3	175.72	0.84	0.0032	1.6814	3.88	3.54
	30.8	1440	1.0051	5.1	5.6	178.48	0.78	0.0013	2.5756	4.08	3.71

Table C4 (b) GRADING OF THE FIELD COMPACTED SAMPLE FOR GR (B)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 2000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing (%)
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			100.0
$1^1/_2$ in	37.10	157.8	7.9	92.1
1 in	26.50	122.1	6.1	86.0
$^3/_4$ in	19.00	70.0	3.5	82.5
$^1/_2$ in	13.20	115.5	5.8	76.7
$^3/_8$ in	9.50	75.6	3.8	72.9
$^1/_4$ in	6.70	130.3	6.5	66.4
$^3/_{16}$ in	4.75	137.6	6.9	59.6
$^1/_8$ in	3.18	222.5	11.1	48.4
No. 7	2.36	145.2	7.3	41.2
No. 14	1.18	12.1	9.9	31.2
No. 25	0.600	4.4	3.6	27.6
No. 36	0.425	1.3	1.1	26.5
No. 52	0.300	1.2	1.0	25.5
NO. 72	0.212	1.3	1.1	24.5
No. 100	0.150	1.1	0.9	23.5
No. 200	0.075	4.9	4.0	19.5
Passing No. 200				
Total		1031.4		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs=** 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:27	27.4	0.5	1.0170	17.0	17.5	131.48	0.839	0.0606	1.6292	15.03	19.46
	27.4	1.0	1.0160	16.0	16.5	135.43	0.839	0.0435	1.6292	14.03	18.17
	27.4	2.0	1.0141	14.1	14.6	142.93	0.839	0.0316	1.6292	12.13	15.71
	27.4	4.0	1.0135	13.5	14.0	145.30	0.84	0.0225	1.6292	11.53	14.93
	27.4	8.0	1.0130	13.0	13.5	147.28	0.84	0.0160	1.6292	11.03	14.28
	27.4	15.0	1.0125	12.5	13.0	149.25	0.84	0.0118	1.6292	10.53	13.63
	27.0	30.0	1.0125	12.5	13.0	149.25	0.85	0.0084	1.5260	10.43	13.50
	27.0	60.0	1.0120	12.0	12.5	151.23	0.85	0.0060	1.5260	9.93	12.85
	26.2	120	1.0115	11.5	12.0	153.20	0.86	0.0043	1.3248	9.22	11.94
	27.6	240	1.0110	11.0	11.5	155.18	0.84	0.0030	1.6814	9.08	11.76
	30.8	1440	1.0090	9.0	9.5	163.08	0.78	0.0012	2.5756	7.98	10.33

Table C5 (a) GRADING OF THE FIELD RAW SAMPLE FOR A-N (SB)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 3000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing (%)
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			100.0
$1^1/_2$ in	37.10	562.4	18.7	81.3
1 in	26.50	509.0	17.0	64.3
$^3/_4$ in	19.00	400.2	13.3	50.9
$^1/_2$ in	13.20	439.7	14.7	36.3
$^3/_8$ in	9.50	224.2	7.5	28.8
$^1/_4$ in	6.70	172.0	5.7	23.1
$^3/_{16}$ in	4.75	79.1	2.6	20.4
$^1/_8$ in	3.18	74.1	2.5	18.0
No. 7	2.36	48.2	1.6	16.4
No. 14	1.18	11.2	3.7	12.7
No. 25	0.600	6.6	2.1	10.6
No. 36	0.425	2.2	0.7	9.8
No. 52	0.300	1.8	0.6	9.2
No. 72	0.212	1.5	0.5	8.8
No. 100	0.150	1.1	0.4	8.4
No. 200	0.075	2.4	0.8	7.6
Passing No. 200				
Total		2460.7		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs=** 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	27.4	0.5	1.0155	15.5	16.0	137.40	0.839	0.0619	1.6292	13.53	6.97
	27.4	1.0	1.0148	14.8	15.3	140.17	0.839	0.0442	1.6292	12.83	6.61
	27.4	2.0	1.0138	13.8	14.3	144.12	0.839	0.0317	1.6292	11.83	6.10
	27.4	4.0	1.0130	13.0	13.5	147.28	0.84	0.0227	1.6292	11.03	5.68
	27.4	8.0	1.0126	12.6	13.1	148.86	0.84	0.0161	1.6292	10.63	5.48
	27.4	15.0	1.0117	11.7	12.2	152.41	0.84	0.0119	1.6292	9.73	5.01
	27.0	30.0	1.0110	11.0	11.5	155.18	0.85	0.0085	1.5260	8.93	4.60
	27.0	60.0	1.0100	10.0	10.5	159.13	0.85	0.0061	1.5260	7.93	4.09
	26.2	120	1.0095	9.5	10.0	161.10	0.86	0.0044	1.3248	7.22	3.72
	27.6	240	1.0090	9.0	9.5	163.08	0.84	0.0031	1.6814	7.08	3.65
	30.8	1440	1.0070	7.0	7.5	170.98	0.78	0.0012	2.5756	5.98	3.08

Table C5 (b) GRADING OF THE FIELD COMPACTED SAMPLE FOR A-N (SB)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 2000g

Sieve size		Weight retained (g)	Percentage retained (%)	Percentage passing (%)
BS designation	Metric (mm)			
3 in	75.00			
$2^1/_2$ in	63.00			
2 in	53.00			100.0
$1^1/_2$ in	37.10	336.4	16.8	83.2
1 in	26.50	97.5	4.9	78.3
$^3/_4$ in	19.00	170.6	8.5	69.8
$^1/_2$ in	13.20	201.0	10.1	59.7
$^3/_8$ in	9.50	102.0	5.1	54.6
$^1/_4$ in	6.70	108.2	5.4	49.2
$^3/_{16}$ in	4.75	60.1	3.0	46.2
$^1/_8$ in	3.18	71.6	3.6	42.6
No. 7	2.36	49.6	2.5	40.1
No. 14	1.18	8.6	6.9	33.2
No. 25	0.600	7.7	6.2	27.1
No. 36	0.425	2.7	2.2	24.9
No. 52	0.300	2.3	1.9	23.0
No. 72	0.212	1.9	1.5	21.5
No. 100	0.150	1.2	0.9	20.6
No. 200	0.075	2.8	2.2	18.4
Passing No. 200				
Total		1147.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 **Gs=** 2.75

Time	Temp, T (oc)	Elapsed time, t (min)	Direct hydrometer reading, RH'	Transformed hydrometer reading, Rh'	Rh=Rh'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M_t	$R_d=R_h'+M_t-R_o'$	K (%)
11:46	27.4	0.5	1.0150	15.0	15.5	139.38	0.839	0.0624	1.6292	13.03	16.42
	27.4	1.0	1.0140	14.0	14.5	143.33	0.839	0.0447	1.6292	12.03	15.16
	27.4	2.0	1.0136	13.6	14.1	144.91	0.839	0.0318	1.6292	11.63	14.66
	27.4	4.0	1.0134	13.4	13.9	145.70	0.84	0.0225	1.6292	11.43	14.40
	27.4	8.0	1.0130	13.0	13.5	147.28	0.84	0.0160	1.6292	11.03	13.90
	27.4	15.0	1.0123	12.3	12.8	150.04	0.84	0.0118	1.6292	10.33	13.02
	27.0	30.0	1.0115	11.5	12.0	153.20	0.85	0.0085	1.5260	9.43	11.88
	27.0	60.0	1.0110	11.0	11.5	155.18	0.85	0.0060	1.5260	8.93	11.25
	26.2	120	1.0105	10.5	11.0	157.15	0.86	0.0043	1.3248	8.22	10.37
	27.6	240	1.0103	10.3	10.8	157.94	0.84	0.0030	1.6814	8.38	10.56
	30.8	1440	1.0089	8.9	9.4	163.47	0.78	0.0012	2.5756	7.88	9.93

Table C6 (a) GRADING OF THE FIELD RAW SAMPLE FOR AJ-AD (SB)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 2500g

Sieve size		Weight retained	Percentage retained	Percentage passing
BS designation	Metric (mm)	(g)	(%)	(%)
3 in	75.00			
2½ in	63.00			
2 in	53.00			100.0
1½ in	37.10	356.2	14.2	85.8
1 in	26.50	106.1	4.2	81.5
¾ in	19.00	49.7	2.0	79.5
½ in	13.20	105.1	4.2	75.3
⅜ in	9.50	115.0	4.6	70.7
¼ in	6.70	210.0	8.4	62.3
⅕ in	4.75	186.5	7.5	54.9
⅛ in	3.18	234.1	9.4	45.5

Sieve size		Weight retained	Percentage retained	Percentage passing
BS designation	Metric (mm)	(g)	(%)	(%)
No. 7	2.36	135.0	5.4	40.1
No. 14	1.18	7.8	6.2	33.9
No. 25	0.600	10.5	8.4	25.5
No. 36	0.425	4.6	3.7	21.8
No. 52	0.300	4.1	3.3	18.6
No. 72	0.212	3.2	2.6	16.0
No. 100	0.150	1.0	0.8	15.2
No. 200	0.075	4.7	3.7	11.4
Passing No. 200				
Total		1362.7		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp. T (oc)	Elapsed time, t (min)	Direct hydrometer reading, R1f'	Transformed hydrometer reading, R1'	R1=R1'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M	$R_1=R_1'+M_t-R_o'$	K (%)
11:17	27.4	0.5	1.0100	10.0	10.5	159.13	0.839	0.0666	1.6292	8.03	10.12
	27.4	1.0	1.0095	9.5	10.0	161.10	0.839	0.0474	1.6292	7.53	9.49
	27.4	2.0	1.0090	9.0	9.5	163.08	0.839	0.0337	1.6292	7.03	8.86
	27.4	4.0	1.0086	8.6	9.1	164.66	0.84	0.0240	1.6292	6.63	8.35
	27.4	8.0	1.0082	8.2	8.7	166.24	0.84	0.0170	1.6292	6.23	7.85
	27.4	15.0	1.0080	8.0	8.5	167.03	0.84	0.0125	1.6292	6.03	7.60
	27.0	30.0	1.0075	7.5	8.0	169.00	0.85	0.0089	1.5260	5.43	6.84
	27.0	60.0	1.0072	7.2	7.7	170.19	0.85	0.0063	1.5260	5.13	6.46
	26.2	120	1.0068	6.8	7.3	171.77	0.86	0.0045	1.3248	4.52	5.70
	27.6	240	1.0065	6.5	7.0	172.95	0.84	0.0032	1.6814	4.58	5.77
	30.8	1440	1.0055	5.5	6.0	176.90	0.78	0.0013	2.5756	4.48	5.64

Table C6 (b) GRADING OF THE FIELD COMPACTED SAMPLE FOR AJ-AD (SB)

Wet Seiving over 2.36mm BS Test Seive. Total Dry Weight 1500g

Sieve size		Weight retained	Percentage retained	Percentage passing
BS designation	Metric (mm)	(g)	(%)	(%)
3 in	75.00			
2½ in	63.00			
2 in	53.00			
1½ in	37.10			
1 in	26.50			100.0
¾ in	19.00	48.6	3.2	96.8
½ in	13.20	52.7	3.5	93.2
⅜ in	9.50	80.4	5.4	87.9
¼ in	6.70	149.4	10.0	77.9
⅕ in	4.75	119.2	7.9	70.0
⅛ in	3.18	203.3	13.6	56.4

Sieve size		Weight retained	Percentage retained	Percentage passing
BS designation	Metric (mm)	(g)	(%)	(%)
No. 7	2.36	130.5	8.7	47.7
No. 14	1.18	12.1	11.6	36.2
No. 25	0.600	10.9	10.4	25.8
No. 36	0.425	3.9	3.7	22.1
No. 52	0.300	3.3	3.1	18.9
No. 72	0.212	2.6	2.5	16.4
No. 100	0.150	1.7	1.6	14.8
No. 200	0.075	2.7	2.5	12.3
Passing No. 200				
Total		653.5		

Hydrometer test for material passing 2.36mm BS Test Seive. Total Dry Weight (g) 50.0 Gs= 2.75

Time	Temp. T (oc)	Elapsed time, t (min)	Direct hydrometer reading, R1f'	Transformed hydrometer reading, R1'	R1=R1'+Cm	Effective depth, Hr (mm)	Viscosity, h (mPa.s)	D (mm)	M	$R_1=R_1'+M_t-R_o'$	K (%)
1:04	27.4	0.5	1.0082	8.2	8.7	166.24	0.839	0.0681	1.6292	6.23	9.34
	27.4	1.0	1.0077	7.7	8.2	168.21	0.839	0.0485	1.6292	5.73	8.59
	27.4	2.0	1.0074	7.4	7.9	169.40	0.839	0.0344	1.6292	5.43	8.14
	27.4	4.0	1.0071	7.1	7.6	170.58	0.84	0.0244	1.6292	5.13	7.69
	27.4	8.0	1.0070	7.0	7.5	170.98	0.84	0.0173	1.6292	5.03	7.54
	27.4	15.0	1.0068	6.8	7.3	171.77	0.84	0.0126	1.6292	4.83	7.24
	27.0	30.0	1.0062	6.2	6.7	174.14	0.85	0.0090	1.5260	4.13	6.19
	27.0	60.0	1.0059	5.9	6.4	175.32	0.85	0.0064	1.5260	3.83	5.74
	26.2	120	1.0055	5.5	6.0	176.90	0.86	0.0046	1.3248	3.22	4.83
	27.6	240	1.0053	5.3	5.8	177.69	0.84	0.0032	1.6814	3.38	5.07
	30.8	1440	1.0040	4.0	4.5	182.83	0.78	0.0013	2.5756	2.98	4.46

Table: C7 Field density test by sand replacement method for T-K (SB) after field Compaction

Test No.	1	2	3
A. Wt. of wet soil sample from hole (gm)	7257	7217	7247
B. Wt. of sand + cyl. before pouring (gm)	9302	9302	9302
C. Wt. of sand + cyl. after pouring (gm)	3408	3417	3411
D. Wt. of sand in (hole + cone) (gm) = B-C	5894	5885	5891
E. Wt. of sand in cone (gm)	1589	1589	1589
F. Wt. of sand in hole (gm) = D-E	4305	4296	4302
G. Bulk density of sand (gm/cc)	1.39	1.39	1.39
H. Wet density of soil gm/cc = (G x A) / F	2.34	2.34	2.34
I. Moisture Content of soil (Speedy tester (%))	7.8	7.9	7.8
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	2.17	2.16	2.17
K. Laboratory Maximum dry density.	2.333	2.333	2.333
L. Percent compaction {(100 x J) / K}	93.2	92.8	93.1

Table:C8 Field density test by sand replacement method for JZ-Y (SB) after field compaction

Test No.	1	2	3
A. Wt. of wet soil sample from hole (gm)	6629	6540	6689
B. Wt. of sand + cyl. before pouring (gm)	9230	9230	9230
C. Wt. of sand + cyl. after pouring (gm)	3337	3405	3309
D. Wt. of sand in (hole + cone) (gm)	5893	5825	5921
E. Wt. of sand in cone (gm)	1598	1598	1598
F. Wt. of sand in hole (gm)	4295	4227	4323
G. Bulk density of sand (gm/cc)	1.542	1.542	1.542
H. Wet density of soil gm/cc = (G x A) / F	2.38	2.39	2.39
I. Moisture Content of soil (Speedy tester (%))	8.3	8.4	8.2
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	2.20	2.20	2.21
K. Laboratory Maximum dry density.	2.23	2.23	2.23
L. Percent compaction {(100 x J) / K}	98.5	98.7	98.9

Table: C9 Field density test by sand replacement method for GR (B) after field Compaction

Test No.	1	2	3
A. Wt. of wet soil sample from hole (gm)	6121	6136	6150
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	1400	1400	1380
D. Wt. of sand in (hole + cone) (gm)	4600	4600	4620
E. Wt. of sand in cone (gm)	1279	1279	1279
F. Wt. of sand in hole (gm)	3321	3321	3341
G. Bulk density of sand (gm/cc)	1.28	1.28	1.28
H. Wet density of soil gm/cc = (G x A) / F	2.36	2.36	2.36
I. Moisture Content of soil (Speedy tester (%))	7.5	7.5	7.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	2.19	2.20	2.19
K. Laboratory Maximum dry density.	2.17	2.17	2.17
L. Percent compaction {(100 x J) / K}	101.1	101.4	101.1

Table: C10 Field density test by sand replacement method for A-N (SB) after field Compaction

Test No.	1	2	3
A. Wt. of wet soil sample from hole (gm)	7434	7624	7698
B. Wt. of sand + cyl. before pouring (gm)	7000	7000	7000
C. Wt. of sand + cyl. after pouring (gm)	1050	950	900
D. Wt. of sand in (hole + cone) (gm)	5950	6050	6100
E. Wt. of sand in cone (gm)	1700	1700	1700
F. Wt. of sand in hole (gm)	4250	4350	4400
G. Bulk density of sand (gm/cc)	1.381	1.381	1.381
H. Wet density of soil gm/cc = (G x A) / F	2.42	2.42	2.42
I. Moisture Content of soil (Speedy tester (%))	8.3	8.4	8.2
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	2.23	2.23	2.23
K. Laboratory Maximum dry density.	2.26	2.26	2.26
L. Percent compaction {(100 x J) / K}	98.7	98.8	98.8

Table: C11 Field density test by sand replacement method for AJ-AD after field Compaction

Test No.	1	2	3
A. Wt. of wet soil sample from hole (gm)	5266	5279	5297
B. Wt. of sand + cyl. before pouring (gm)	6000	6000	6000
C. Wt. of sand + cyl. after pouring (gm)	1344	1347	1339
D. Wt. of sand in (hole + cone) (gm)	4656	4653	4661
E. Wt. of sand in cone (gm)	1514	1514	1514
F. Wt. of sand in hole (gm)	3142	3139	3147
G. Bulk density of sand (gm/cc)	1.37	1.37	1.37
H. Wet density of soil gm/cc = (G x A) / F	2.30	2.30	2.31
I. Moisture Content of soil (Speedy tester (%))	9.4	9.4	9.4
J. Dry Density of sample [(Hx 100gm/cc)/(100 + I)]	2.10	2.11	2.11
K. Laboratory Maximum dry density.	2.066	2.066	2.066
L. Percent compaction {(100 x J) / K}	101.6	101.9	102.0