TRAINING OF FIREFIGHTERS: A CASE FOR THE PROVISION OF BASIC AND SPECIALIZED FACILITIES

by

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Bsc. Architecture (Hons)

A Thesis submitted to the Department Of Architecture,

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in partial fulfilment of the requirements for the degree

of

MASTER OF ARCHITECTURE

Faculty of Architecture and Building Technology,

College of Architecture and Planning

November 2010

ABSTRACT

In the wake of recent fire outbreaks in Ghana which have resulted in the loss of property and in some fatalities, the competence of the Ghana National Fire Service has been brought to the fore, especially with regard to their training. Currently, there is only one firefighting training school in Ghana and as a result, the facilities available (most of which were not purposely designed for the functions to which they are being used) are subjected to a lot of pressure. Through careful studies and analysis of similar fire service facilities in other countries, the standard components required for firefighting training schools in terms of facilities, both basic and specialized are established. The materials and design elements specified for the various buildings in a firefighting training school are also established. This research concludes that firefighting should not be underestimated. Every effort should be made to provide the best and appropriate facilities and environment for its training as this will eventually lead to an overall improvement in the response and performance of firefighters to distress calls. This will ultimately lead to a reduction in the damage and casualties resulting from fire outbreaks in Ghana.

DECLARATION

I hereby declare that this submission is my own work towards the M.Arch and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ACKNOWLEDGEMENT

First and foremost, my sincere thanks go to the Almighty God for sustaining me through my six-year education in Kwame Nkrumah University of Science and Technology. My heartfelt appreciation also goes to my parents, Mr. and Mrs. Yeboah Mensah and my sister, Amma Nyarko Mensah, whose support has brought me this far.

My sincere gratitude goes to Mr. Daniel Duah and Rev. Fr. Dr. Quagraine, both of the Department of Architecture, KNUST for their immense help and guidance during this thesis. My deepest appreciation also goes to the following personalities whose help in diverse ways made this research work a reality:

Mr. Franklin Masiku, PRO, Ashanti Regional Headquarters of the Ghana National Fire Service.

Mr. Edward Okantey, of the Fire Academy and Training School, Accra.

Mr. Daniel Quaye, of the Fire Academy and Training School, Accra.

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1.1 INTRODUCTION

Fire, a reaction involving fuel and oxygen that produces heat and light has been used by people over a long period of time. Early humans used fire to warm themselves, cook food and frighten away predators. Over the years, people discovered more uses of fire including the provision of light, the production of tools as well as a weapon in times of war. Today, people use fire in so many ways and they focus on the productive use of fire as well as the prevention of unwanted fire.

If not used carefully, fire can be very destructive. As the old saying goes, "Fire is a good servant but it can be a bad master too". This is evident in the number of fire outbreaks across the world. Even though fire was very useful in the olden days, it posed great risks and challenges to early people including the threat of burns, the challenges of controlling fire and the threat of wild or bush fires. Today, fire still remains a potentially destructive force in human lives (Microsoft Encarta, 2008).

Even though most serious fires are caused by human activities, some natural fires caused by lightning and volcanoes can result in bushfires or forest fires which cause widespread devastation (Microsoft Encarta, 2008). Some human activities which usually result in fire outbreaks may include the careless disposal of cigarettes and matches or the carelessness associated with bush burning which may eventually result in bush or forest fires. Other causes of fire out breaks could be due to electrical faults.

The increasing number of fire out breaks in recent times, especially in Ghana is quite alarming and about 90% of these fires have resulted in the loss of property worth millions of cedis, and also in casualties that have resulted in the loss of human lives (Ghana National Fire Service, 2008). This has created a great sense of the awareness of fire and has brought the work of the personnel of the Ghana National Fire Service to the fore since the service is the only statutory body (established on the 11th of December, 1963 by an Act of Parliament, Act219) in the country that is charged with the task of extinguishing fire or bringing fire outbreaks under control, be it domestic, commercial, industrial or bush fires (Ghana National Fire Service, 2008).

In the wake of recent fire outbreaks, the Ghana National Fire Service has come under much criticism as to the competence of its firefighters in relation to their response to fire, their ability to extinguish or bring such fires under control as well as their ability to salvage lives and property from destruction in the event of fire outbreaks.

1.2 PROBLEM STATEMENT

In recent times, the frequency of fire outbreaks (be it domestic, commercial, industrial and bush fires) in Ghana has dominated news headlines both in the print and electronic media since the extent of damage to human lives and property is quite alarming. In the year 2007, a total of two thousand, eight hundred and nineteen (2,819) fire outbreaks were recorded in Ghana. These included domestic, industrial, vehicular, institutional, electrical, commercial and bush fires. All these resulted in casualties including deaths as well as damage and loss of property (Ghana National Fire Service, 2008). Statistics of fire outbreaks that occurred in the various regions of Ghana in 2007, the rescue attempts and the cost are shown in Table 1.1.

Table 1.1: Statistics of fire outbreaks in Ghana and associated cost of damage for 2007 (Source: Ghana National Fire Service, 2008).

FOR THE YEAR 2007

REGION	RESCUE			FIRE OUTBREAK				DOMESTIC	INDUSTRIAL	VEHICULAR	INSTITU-TIONAL	ELECTRICAL	COMMERCIAL	BUSH	OTHER	TOTAL
	NO.	INJURY	DEATH	INJURY	DEATH	COST OF DAMAGE (GHC)	COST OF SALVAGE .(GHC)									
ASHANTI	120	262	33	0	0	3,941,624.80		364	50	65	5	44	61	109	19	717
BRONG AHAFO	10	2	3	2	1	767,697.00	5,251.00	64	10	20	1	7	7	28	7	144
CENTRAL	55	27	47	6	0	301,206.20	228,143.00	59	3	15	2	13	6	38	173	309
EASTERN	41	188	17	2	2	186,778.20		121	13	21	1	16	15	78	2	267
GREATER ACCRA	4	0	0	1	2			233	14	37	19	33	58	16	13	423
NORTHERN	0	0	0	0	2	112,827.00		39	0	12	2	3	5	2	2	65
TEMA	23	0	2	6	2			126	14	32	0	55	23	12	20	282
UPPER EAST	19	1	0	0	0	11,500.00		17	2	2	0	2	1	18	116	158
UPPER WEST	2	0	0	0	0			0	0	0	0	2	0	0	125	127
VOLTA	0	0	0	0	0	31,431.00		17	0	2	0	2	0	9	0	30
WESTERN	0	0	0	18	1	1,956,208.56		79	13	14	0	19	24	31	21	201
HEADQUARTERS	5	13	2	0	0	30,500.00		44	0	8	1	14	24	2	3	96
FIRE ACADEMY & TRAINING SCHOOL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	279	493	104	35	10	7,339,772.76	233,394.00	1163	119	228	31	210	224	343	501	2819
% OF FIRE OUTBREAKS								41.456%	4.22136%	8.088%	1.09968%	7.44945%	2.9461%	12.17 %	17.772%	100%

Numerous questions have been raised about the credibility of the Ghana National Fire Service since firemen more often than not arrive late at the scenes of fire outbreaks and in most cases cannot do much to help salvage human lives and property. The inability of firefighters to perform their duties well is as a result of the lack of the requisite number of trained personnel deployed to the scene of a fire outbreak (Ghana National Fire Service, 2008).

The Ghana National Fire Service lacks the adequate number of trained personnel to deal with the ever increasing number of fire outbreaks in the country. Ideally, the ratio of firefighters per population is 1:800 (Ghana National Fire Service, 2008). Currently, there are six thousand (6000) firemen in Ghana (Ghana National Fire Service, 2008) which has a total population of twenty-two million (22,000,000) people. The ratio of firefighters per population in Ghana is therefore 1:3667 which is woefully inadequate.

The inadequacy of trained personnel is largely due to the inadequacy of appropriate firefighting training facilities required to fully equip firefighters to efficiently carry out their duties which aim at saving lives, property and offering humanitarian services in times of fire outbreaks and other natural disasters like floods which require their services (Ghana National Fire Service, 2008).

Currently, the Ghana National Fire Service has only one training school which trains all firefighters in the country and this to a large extent limits the number of personnel trained. The Fire Academy and Training School (FATS), which is the only facility available for training firefighters in the country, currently admits a total number of two hundred and fifty (250) to three hundred (300) recruits per training which covers a period of six (6) months. Officer Cadets are also trained for a period of nine (9) months (Ghana National Fire Service, 2008).

This training school was however not purposely designed for its use since the premises on which they operate was given out to the Ghana National Fire Service after having served as a warehouse for Mobil Ghana for a while (Ghana National Fire Service, 2008). As such, it is highly under equipped owing to the fact that some relevant and mandatory facilities specifically those required for the practical aspect of firefighting training are absent. Thus, firefighters are exposed to a limited number of live-fire scenarios since the quality of training is inadequate.

1.3 JUSTIFICATION

First of all, the inadequate number of trained fire personnel to help fight fire coupled with the unavailability of the appropriate facilities at the only training school, the Fire Academy and Training School, has necessitated this research to be conducted to establish the various facilities needed in the training of firefighters in Ghana.

Also, the alarming rate of the loss of human lives and property (as illustrated in Table 1.1) as a result of fire outbreaks is mostly due to the slow rate of response of personnel of the Ghana National Fire Service to the scenes of the fire outbreaks. Personnel must therefore be trained to be able to readily respond to fire. This can be achieved through the provision of the appropriate facilities, equipment and materials for training.

1.4 OBJECTIVES

The main aim of this research is to design a model firefighting training centre that includes the appropriate facilities (basic and specialized), and infrastructure that enhance the control of fire outbreaks. The details include the following:

- to establish the appropriate design principles of firefighting training centres.
- to determine the appropriate basic and specialized facilities to be included in firefighting training centres.
- to determine the materials and design elements for construction.
- to determine the accompanying infrastructure for firefighting training centres.

1.5 SCOPE

The thesis will include an in-depth research into the training of firefighters in Ghana, with the study of better performing academies as a basis.

1.6 RESEARCH METHODOLOGY

This section explains the method through which data was collected to complete this thesis.

1.6.1 Sources of Data

The sources of data used for this research included interviews, photography, case studies and literature review.

1.6.1.1 Interviews

Interviews were conducted among some personalities with knowledge on the topic to establish some facts on the training of firefighters in general and in Ghana for the purposes of the thesis.

1.6.1.2 Photography

Relevant photographs pertaining to the research work were documented.

1.6.1.3 Literature review

References were taken from both the library and the e- library (internet) which included books, journals, reports, conference papers, periodicals and research projects. Both local and foreign facilities of the same or similar functions were also studied to determine the training facilities and various materials used in their construction.

CHAPTER TWO: LITERATURE REVIEW

This chapter of the thesis reviews literature on firefighting, the evolution of firefighting in Ghana, planning considerations for the siting of firefighting training centres, the components of firefighting training schools, as well as the various materials and design elements employed in firefighting training schools.

2.1 FIREFIGHTING

Wikipedia (2008) defines firefighting as the act of extinguishing destructive fires. Such fires are usually fought by firefighters to prevent the destruction of life, property and the environment. Being a highly technical profession, the proficiency of a firefighter greatly depends on several years of training. Firefighters can also be described as extensively trained rescuers whose primary aims are to extinguish hazardous fires which threaten civilian population and property, to rescue people from burning and collapsed buildings as well as from car accidents (Wikipedia, 2008). This assertion brings to light the fact that firefighters are not only trained to put out fires but to a large extent, perform emergency duties as well and as such training facilities for such drills must be provided.

Firefighters need several basic skills: prevention, self preservation, rescue, preservation of property and fire control. Firefighting is further broken down into the following: search and rescue (usually performed very early at any fire scenario), size- up, extinguishing, ventilation, salvage and overhaul (Wikipedia, 2008). Firefighters must be properly trained in all these skills, mostly through the provision of the appropriate training facilities to cope with the numerous scenarios of fire outbreaks.

2.1.1 Evolution of Fire Fighting in General

The history of fire fighting dates back many centuries but first attempts at organized fire fighting could be traced to Ancient Egypt as far back as the second century where hand-operated pumps were employed to extinguish fire. Rome also suffered a series of fire outbreaks. Notable amongst them was the fire that started near the Circus Maximus and nearly destroyed two-thirds of Rome on the 19th of July, AD 64. Organized methods of firefighting later spread through Europe and the United States (Wikipedia, 2008).

2.1.1.1 Fire Fighting in Europe

Fire fighting in Europe was quite fundamental until the 17th century when residents of Paris were allowed to establish their own night watches to prevent and stop crimes and fires. The city of Paris was the scene of several great fires in the 16th century. The city of London also experienced a great number of fires in AD 789, 982, and 989 but suffered a catastrophic fire, the Great Fire of London in 1666. This fire destroyed about two square miles of the city rendering thousands of people homeless. The only equipment available to fight this fire which burned for four days consisted of two-quart hand syringes and a similar, slightly larger syringe. Prior to this great fire, there was no organized fire protection system present in London. The Great Fire of London stimulated the development of a two-person operated piston pump on wheels (Wikipedia, 2008).

2.1.1.2 Fire Fighting in the United States

Fire outbreaks were rampant in the United States. In 1631, the then governor of Boston, John Winthrop outlawed the use of wooden chimneys and thatched roofs in a bid to reduce fire outbreaks. Later, fire wardens were appointed and empowered to inspect chimneys and fine any violators of the rule. “Rattle Watch” was later introduced and this involved men who patrolled the streets at night carrying large wooden rattles which they spun on noticing a fire. This directed the responding citizens to form bucket brigades. The fire service began in the colonial United States in Boston in 1680 (Wikipedia, 2008).

The formation of volunteer fire departments was started by Benjamin Franklin in 1735 in Philadelphia which eventually led to the establishment of the Union Fire Company, also in Philadelphia. George Washington who was a volunteer firefighter in Alexandria, Virginia donated a new fire engine (which he imported from England) to the town which was its first. In spite of this, the United States did not have professional firefighters who run government owned fire departments until around the time of the American Civil War. Earlier on, unprofessional fire brigades would compete among themselves to be the first to respond to a fire so they could get paid by the insurance companies since that was the norm of that time (Wikipedia, 2008).

2.1.1.3 Some Early Fire Fighting Techniques

In the early days, most fire companies were volunteer or privately operated. There was some amount of competition for services. Thus, the fire company that was able to make it to the scene of the fire first, hook up to a hydrant and extinguish the fire was paid by the insurance companies. Apart from their strength in fighting fire, fire fighters were recruited for their ability to protect the company for which they worked as well as its equipment. The tools of the trade in the early days were leather buckets, hooks and chains, swabs, ladders, and some archaic pumps (Wikipedia, 2008).

The first fire departments were “Bucket Brigades” where laws often required residents to purchase fire buckets, have the names of the owners inscribed on them and maintain them. In the 1680s, in New York, the number of buckets a home or business required was determined by the risk of the fire. For example, a baker must have three buckets and a brewer six buckets in case of fire (Wikipedia, 2008).

These bucket brigades mainly consisted of two lines of people stretching from the town well to the scene of the fire. They passed buckets of water to the fire, and empty buckets back to the well to be refilled. Using the human chain, a continuous supply of buckets provided an almost constant supply of water. Later, with the invention of the hand pumper, the bucket brigades were used to keep the pumper full of water. With the hand pumper, the foreman of the pump companies would use a large "speaking trumpet" to give orders and urge his crew on. Hooks and chains were also used to make fire breaks by pulling down walls of burning buildings to keep the fire from spreading. Swabs were used to extinguish embers on thatch roofs (Wikipedia, 2008).

2.1.1.4 Development of Firefighting Equipment

After many attempts at fighting fire, the key breakthrough in firefighting occurred in the 17th century with the invention of the fire engines. Manual pumps which were discovered in Europe after 1500 were only force pumps which had a very short and limited range due to the lack of hoses. This manual pump was improved with the creation of the suction and force pumps with additional flexible hoses. The fire hose was eventually invented in1672 by a Dutch, Jan Van der Heyden and was manufactured from flexible leather and fastened with brass fittings at 50 feet (15 metres) intervals. This length, together with the connections remains the standard to this day (Wikipedia, 2008). The fire engine was developed in London in 1725 by Richard Newsham. It was manually operated and pulled as a cart to the scene of the fire and could deliver up to 160 gallons per minute at up to about 120 feet (40 metres) high. A steam fire engine was invented in 1829 and subsequently a self- propelled engine was built in 1841. The aerial ladder wagon was invented in 1870 with the hose elevator being introduced in 1871. By the late 1800s, horsedrawn, steam-driven fire pumpers were in vogue. These steam pumpers were replaced in 1910 with a diesel powered engine which combined the two functions of propelling the truck and driving the pump. This invention with its numerous variations generally enhance the response times of firefighters to all kinds of emergency situations (Wikipedia, 2008).

2.2 EVOLUTION OF FIREFIGHTING IN GHANA

Prior to the establishment of the Ghana National Fire Service, there was no major statutory body set up purposely to undertake fire fighting activities. Various individual and state owned companies in the country formed groups and squads that embraced the task of fighting fires that occurred in these establishments. One such body was the Railway and Harbours Administration at Sekondi, in the Western Region of Ghana, which established a part-time fire brigade in the mid 1920's to safeguard their location workshops. The Brigade was purposely set up to see to the fire protection of property of the Railway and Harbours in the Sekondi/Takoradi vicinity. Even though full time firefighting activities were established in Ghana during the Second World War (1939- 1945), the absence of efficient firefighting equipment and appliances which could ensure the effective delivery of services by firefighters accounted for the use of sand and water only in the events of fire outbreaks (Ansah, 1973).

The first batch of full time firefighters was trained in 1942 at the Civil Defence Fire Service Centre, the fire service unit of the Civil Defence Corps in Sekondi. This service was mainly formed to prevent fire and provide the necessary protection for the Takoradi Port and its environs during the war (Ansah, 1973).

Before the Second World War, foreign airline companies maintained fire protection and prevention units in aerodromes as well as air strips in the country until the Royal Air Force took over the fire services offered by the aerodromes. These services were however taken over by the Air Services Department (currently the Department of Civil Aviation), in 1946 when the Royal Air Force withdrew from the country. Voluntary fire squads were also established both in Accra and Kumasi just before the Second World War and were subsequently recruited into the Civil Defence Fire Service during the war and returned to their individual companies after the war. The three main fire squads that existed in the country were;

- The Railway and Harbour Unit
- The Civil Aviation Unit and
- The Cities and Towns Unit (Ansah, 1973).

2.3 COMPONENTS OF FIREFIGHTING TRAINING CENTRES

Firefighting training schools consist of a number of facilities or components. Elmore (2001) states that "as long as the purpose of an individual component is not compromised, each component can be located wherever it is conducive for effective training and safety in the school". National Fire Protection Association, NFPA (2001) categorizes these standard components into four main groups namely

- Indoor instructional facilities
- Outside facilities
- Administration and support facilities

- Site/ exterior facilities

2.3.1 Indoor Instructional Facilities

Indoor instructional facilities comprise classrooms for the theoretical aspect of training, an auditorium for indoor training activities, physical fitness area for the physical training of firefighters, and a pool for water rescue training. Others are technical rescue training areas for urban search and rescue operations, special training laboratory (for simulators, automatic sprinklers, pumps and fire alarm systems) and storage space for equipment and props (NFPA, 2001).

2.3.2 Outside facilities

Outside facilities consist of the drill tower for rappelling and ladder evolutions, the drafting pit for the operation of pumping apparatus from a draft, live fire training structure for live fire evolutions, motor vehicle driving range, flammable liquids and gases/ distribution area, hazardous materials area and decontamination area, and outside classroom areas. The rest are helicopter landing site, respiratory protection training laboratory for breathing apparatus evolutions, storage space for portable equipment, vehicle and props, seating for outdoor classes or observation of drill tower activities, fire station and safety and monitoring control areas (NFPA, 2001).

2.3.3 Administration and Support Facilities

Administrative and support facilities include offices, conference areas, library, photo laboratory, printing/copying area, graphics/audiovisual aid preparation area, student housing, dormitories and recreational facilities, cafeteria, restroom and locker facilities, apparatus maintenance and repair centre, equipment and supply facility, and storage space for various materials. Others are communication centres, data processing centre, medical area/ infirmary, computer facilities and multimedia facilities (NFPA, 2001).

2.3.4 Site/exterior facilities

Site and exterior facilities include water distribution, sewer and other utilities, parking facilities, site maintenance equipment and facilities, communications and water filtration systems (NFPA, 2001).

2.4 PLANNING CONSIDERATIONS AND SITING OF FIREFIGHTING TRAINING SCHOOLS

2.4.1 Planning Considerations

Some guidelines must be considered when planning for a specialized facility such a firefighting training school (NFPA, 2001). Some of these guidelines as proposed by NFPA 1402 (2001) – Guide to Building Fire Training Centres are enumerated below.

1. The area master plan and zoning criteria should be taken into consideration to avoid conflicts. The training facility should be sited away from the centre of community life to minimize the negative impact on adjacent land use.

2. An environmental impact assessment should be done. This clearly spells out the objectives and alternatives of the proposed firefighting training centre and identifies the effect of the intended activities of the training centre on the environment. Measures for the mitigation and management of the identified effects (pollution of the air by smoke generated by live fire training sessions) are then proposed.

3. It is necessary to prevent or minimize possible accidents which may result from the use of water for training. As such, slip-resistant surfaces such as concrete slabs and rough terrazzo finishes should be specified for all stairs and well-travelled paths to avoid the risk of accidents during training activities.

4. Automatic sprinklers and smoke detectors should be specified for appropriate areas for early fire detection and prevention.

2.4.2 Siting of Firefighting Training Schools/Centres

The siting of a firefighting training facility in a community is determined by some pertinent factors which include the location and size of site, water supply, environmental considerations, and access to utilities (Elmore, 2001).

2.4.2.1 Location and Size of Site

The area master plan should be taken into consideration. The site chosen for the training facility should preferably be located away from the centre of community life to minimize negative impacts on adjacent land use. The area master plan must be checked to confirm the zoning of land use in the area. The advantage of siting a firefighting training school in the peri-urban areas of a town, city or country is to ensure that firefighting drills and live fire training sessions are conducted without its related air and noise pollution affecting surrounding facilities. The size of the site should be ample for planned buildings, parking and future expansion. Adequate separation should be planned between buildings for safety, vehicular movement and instructional purposes. It is better to conserve on the size of structures than to overcrowd limited land (Elmore, 2001). This point reiterates the fact that the required size of land for training purposes may not be available in the central business districts hence its preferred location in remote areas.

The most convenient route to the training facility must be chosen after a careful study of vehicle traffic patterns in the area. Travel time to the facility for users should also be taken into consideration. On-duty personnel who are receiving in-service training at the facility could be required to attend to emergency incidents. The facility should be located so that it is accessible to appropriate emergency response routes (Elmore, 2001). The vehicular traffic patterns in the town or city in which the firefighting training school is to be located must be taken into account considering the fact that a fire station (which responds to distress calls) is a standard component of a fire training facility (Mion, 2008). As such, the facility must be positioned to avoid vehicular conflicts so as to increase the response time of firefighters to emergency calls.

2.4.2.2 Water Supply

Firefighting requires the use of water in almost all its training activities: attack lines, back-up lines and pumping exercises. Water is also needed by both students and staff for domestic use in a firefighting training school. Systems to be installed must be able to deliver the necessary volume and pressure for training activities by the provision of a loop or grid system with properly placed valves. Valves should be placed to segregate sections of the water system to allow for repairs without complete shutdown (Elmore, 2001). Firefighting training demands a constant supply of water for both training and domestic use. Apart from the water supply from the mains, water storage tanks, both underground and overhead will be necessary to provide a continuous supply of water for the facility.

Fire hydrants should be installed and these should be the same types located in the community in which the firefighting training centre is situated (NFPA, 2001). This is essentially to provide trainees with the ability to identify and use fire hydrants in case of fire outbreaks in the community. Additional sources such as lakes, ponds and streams can also be used in times of water shortage.

2.4.2.3 Environmental Considerations

NFPA (2001) cites the need for environmental considerations when siting firefighting training schools to ensure that the facility is environmentally safe. The effect of the training school on the environment would mainly be associated with air, water and the soil. The same document recommends the need for an environmental impact assessment to determine what effect, if any, the training facility would have on the environment. This may include pollution of the air by smoke emanating from fires used for training activities.

The prevalent wind direction should be considered when selecting the location of a firefighting training centre. Smoke generated by training activities can easily be channeled away from the surrounding buildings by the use of wind socks (NFPA, 2001). Wind socks can indicate wind direction and speed (Wikipedia, 2008) which in turn will assist fire instructors to assess and estimate the effect of the wind on a particular training activity and take measures such as relocation or rescheduling of that activity to reduce air pollution.

The disposal of waste water from firefighting training procedures must be discharged properly to prevent the ground water from being contaminated. This can be achieved by the use of oil separators and bacteriological breakdowns. The facility should be designed to take full advantage of runoff to replace water used for training (Elmore, 2001). A water treatment plant can also be installed to recycle waste water solely for training purposes.

The type of soil on which the firefighting training school is to be located is very crucial as it affects the types of foundations to be employed as well as the bearing capacity of the soil to support the loads (buildings) to be erected (Elmore, 2001). Elmore (2001) further states that full advantage of the land should be taken to develop runoff patterns and establish locations for various buildings and props. This would ensure there is no interference with the drainage of the water during all seasons and weather conditions.

2.4.2.4 Access to Utilities

Overall power requirements of the facility can be increased immensely by the use of pumps, air compressors, simulators, and heat, ventilation and air conditioning (HVAC) units. Alternatively, an on-site total energy system which provides utility services (electrical, heat and air) can be employed for use in buildings. The largest portion of the electrical needs is dictated by the number of buildings and the purposes for which they are used. Electrical outlets should be installed everywhere necessary to avoid the use of extension cords (Elmore, 2001). This will prevent the tripping of firefighters during training sessions and avoid fatalities (NFPA, 2001).

2.5 DESIGN ELEMENTS FOR THE COMPONENTS OF FIREFIGHTING TRAINING CENTRES

The various components to be included in firefighting training schools as well as the design elements and materials used are discussed. Some components with related functions may be combined into one building if the need arises. For example, the administration and classroom buildings can be combined to produce a feasible administration/ classroom building (NFPA, 2001).

2.5.1 Offices

Office spaces are needed for the officer in charge, the assistant administrator, instructors and clerical staff. Flexibility of these office spaces which can be achieved through the design of open plan offices is an important aspect to be considered. Storage spaces should also be provided (Elmore, 2001).

2.5.2 Classrooms

The size of the classroom is determined by the number of students and the type of training to be conducted in the space. For instance, much more space would be required for each student during hands-on training as compared to the space required during theoretical lectures (NFPA, 2001). Moveable soundproof walls can be used to vary classroom sizes. The provision of adequate aisle space is necessary for proper circulation within the classrooms (Elmore, 2001). The spatial requirements for each classroom may vary depending on its intended use. Provision must therefore be made for different sizes of classrooms to accommodate the various types of training to be conducted (NFPA, 2001).

NFPA (2001) states that, classroom floors should be constructed of heavy duty flooring material such as concrete to help withstand the movement of firefighters with soiled gears. It also states that ceiling heights should be a minimum of 3 metres to allow the hanging of wall screens or the placement of portable screens for good viewing. NFPA (2001) recommends the use of doors which open and close quietly in classrooms. This is mainly to reduce noise in the classrooms which are supposed to be quiet areas for learning. Air conditioning and heating units should not be installed in the classrooms due to the noise they produce (NFPA, 2001). For the same reason as being quiet areas for learning, any installation which would produce noise to interrupt lectures must be avoided. Instead, large windows can be integrated into the design to naturally ventilate the space. Good lighting which is unavoidable in classrooms can be achieved by the use of individual controls to vary illumination as and when needed (Elmore, 2001).

2.5.3 Auditorium

The auditorium can function as a space for seminars, ceremonies, community activities, fitness classes and can also be adapted for use as classrooms when necessary. Due to the diverse functions it can be put to, it is important to design the space to accommodate all the activities at different times. The use of movable seats will enhance the utility of the space as the auditorium can easily be converted from one use to another. The auditorium can also be adapted for use as a facility for basic training activities when inclement weather prevents outside activities. As a result, the floor and wall finishes for the auditorium have to be designed to withstand indoor training sessions (Elmore, 2001).

2.5.4 Locker and Shower Facilities

Locker and shower facilities should include shower rooms, toilets and wash hand basins with mirrors. Separate facilities must be provided for males and females. Ventilation in these spaces is very important (NFPA, 2001). These spaces must be properly ventilated naturally by providing vents and windows or by means of artificial ventilation which would include the use of extractor fans.

2.5.5 Landscaping

The road layout in the training school should reflect that of the community in which the facility is located. Roadways throughout the facility must be interconnected to facilitate easy access of firefighting trainees to all buildings and drill areas in the school (NFPA, 2001).

2.6 'SPECIALIZED' COMPONENTS IN FIREFIGHTING TRAINING CENTRES

Even though many facilities exist in firefighting training schools, emphasis is more often than not placed on particular structures or facilities since they are peculiar to fire fighting, have different methods of construction as well as special elements of design. Some of these structures are the live fire training building (also referred to as the burn building) where real live fire is simulated for the training of students, the drill tower where most of the fire fighting drills such as ladder evolutions and rappelling are carried out, and the smoke building where smoke related training procedures are performed. The fire station which is also considered an important component in firefighting training schools should be well designed to serve its purpose effectively (NFPA, 2001). Their uses, layouts, materials and design elements are discussed below.

2.6.1 Live Fire Training Structure/Burn Building

NFPA (2001) defines a burn building as a structure specifically designed for conducting live fire training evolutions on a repetitive basis. The same document also defines live fire as any unconfined open flame or device that can propagate fire to a building or other combustible materials. The purpose of the live fire training structure is to safely train firefighters in methods of interior fire suppression and its design should take into consideration fire spread, rescue and ventilation (Elmore, 2001). There are three types of burn buildings namely traditional, acquired structures and simulated structural fire buildings (Lawrence, 2008).

a) Traditional burn buildings

Traditional burn buildings are those which are built with special materials such as concrete and can withstand multiple fires although they deteriorate over time. They can be found in communities and at fire academies. The fuel used to set up fire in these traditional burn buildings is usually straw, hay or wood pallets (Lawrence, 2008).

b) Acquired structures

Acquired structures are condemned or abandoned buildings whose structural integrity are inspected and approved by a building inspector as being safe for conducting training exercises. Depending on the extent of damage to the abandoned structure which may provide unsafe conditions for training, some form of repair work may be carried out to make the building safe for live fire training (Lawrence, 2008). Guida (2008) mentions that to create a safe environment for the most realistic training possible, the condemned or abandoned building would have to be prepared by completely cleaning out all wall coverings, furniture and appliances. Ceiling fixtures including lights, bathroom fan covers, HVAC vent covers, kitchen vent pipes, window air conditioning units must also be removed. All windows and interior doors would have to be removed. An easy to exit window covering (a blow out window) would have to be created. This covering works to keep light out and smoke in making the fire more realistic. The blow out window also serves as a means of escape in emergency situations. All exterior doors would have to be changed to swing outwards (Guida, 2008). Despite the preparation of the building for training purposes, the use of an acquired building can still be dangerous (Lawrence, 2008). This is mainly because the abandoned or condemned building may not have been originally designed as a burn building. It may therefore not be structurally sound to carry the heat load produced by the fire. The building may therefore collapse and cause injuries and deaths when being used by firefighters.

c) Simulated structural fire buildings

Simulated structural fire buildings are burn buildings which have computer control built in fire-producing devices. These devices run on propane and natural gas, and use a non flammable aerosol to synthetically create real smoke. The burn building has systems to extinguish fire and extract smoke with the push of a button in case of emergencies (Lawrence, 2008).

2.6.1.1 Layout of Live Fire Training Structures (Burn Buildings)

The internal layout of the live fire training structure would have to be as realistic as possible providing a variety of simulated rooms such as a bedroom, a kitchen or a living room. It is necessary to provide multiple access to the building such as doors at grade, doors above grade and as many windows as possible. The exterior of the burn building needs to be accessible to make attacks from fire apparatus/tenders possible (Cote, 2003).

The provision of various realistic simulated rooms as illustrated in Figure 2.1 ensures that trainees are exposed to a wide range of fire outbreak scenarios which will in turn help in their training to equip them with the necessary skills for fighting such fires. The provision of multiple entry/exit points could serve as a means of escape in emergency situations.

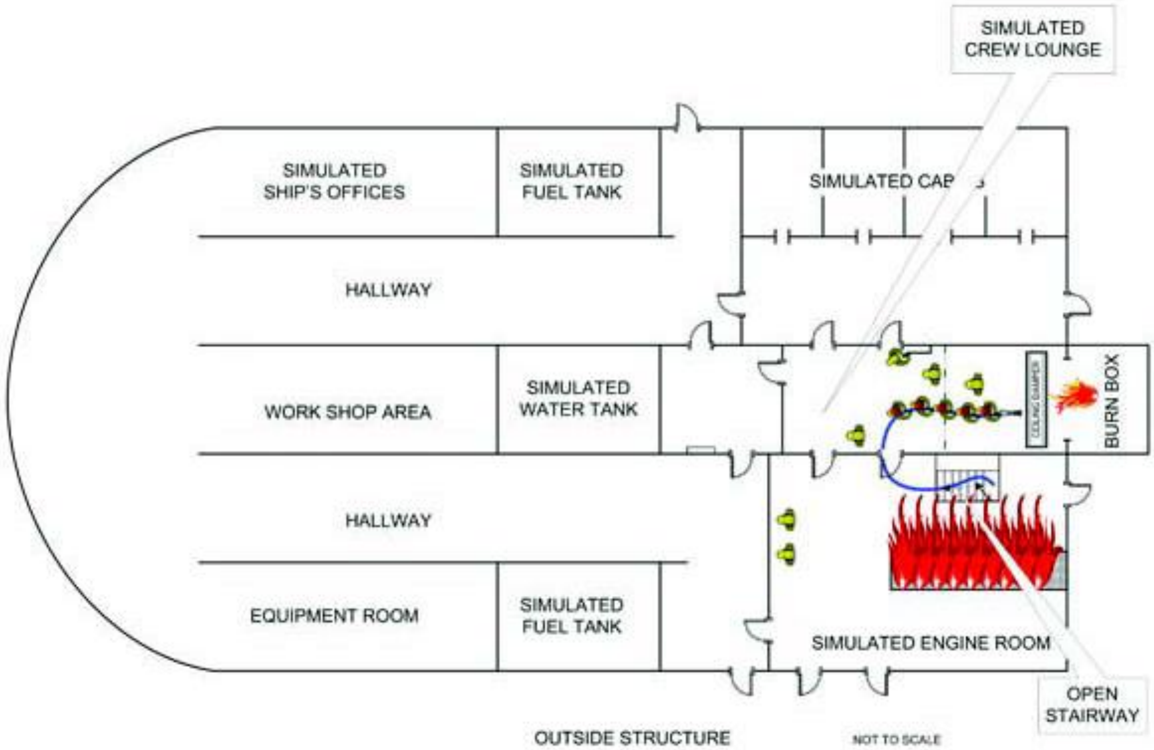


Figure 2.1: Schematic layout of the ground floor of a live fire burn structure (Source: Lawrence, 2008)

2.6.1.2 Materials for the construction of Burn Buildings

Frequent exposure of the burn building to high temperatures during training activities can result in the rapid deterioration of the structural components and its eventual collapse if care is not taken (Lawrence, 2008). The burn building must be designed to withstand a temperature of 2,000+ ^{o} F (1,093+ ^{o} C) produced by training fires. After being heated to high temperatures during live fire training sessions, it is necessary for the building to withstand the change in temperatures when hose streams strike its walls, ceilings and floors (Cote, 2003). As such, walls, floors and ceilings of these live fire training structures are constructed of materials which have strong resistance to heat generated by fire, some of which are masonry, concrete and metals. Heat resistant tiles can also be used as interior finishes for walls and ceilings (Lawrence, 2008).

A number of materials have been tested to be used in the construction of a building that can withstand high temperatures and the rapid changes in temperature. Some of these materials include cast-in-place concrete, masonry and steel (Cote, 2003). Cote states, "All these materials have met with varying success and all eventually break down under the stress that is applied to them". The assertion implies that the materials which have been tested and approved as fire resistant materials gradually deteriorate when subjected to extreme temperatures as in the case of the burn building.

Live fire training buildings are now being constructed with a combination of reinforced concrete, precast pre-stressed concrete and masonry. Panels made from calcium aluminate concrete with lightweight aggregate of high carbon content, refractory blocks (heat-resistant blocks) or steel liners offset from the walls of the burn rooms are used to protect the concrete wall (Cote, 2003). In the specification of interior fire-resistant materials for live fire training structures, the durability, thermal expansion and contraction must be taken into account. Also, the ease of replacement of damaged portions must be considered (Elmore, 2001).

Elmore (2001) suggests that, to protect the structural components of the burn building from the high temperatures, the following materials can be utilized.

1. Non- structural precast modules made from poured calcium aluminate concrete with light weight aggregate of high carbon content. This has a high strength and resistance to spalling.
2. Cementitious concrete can be sprayed on exposed surfaces (a process known as gunning) to ensure protection from fire.
3. Refractory blocks set in refractory mortar can be used.

Both Elmore (2001) and Cote (2003) attest to the fact that calcium aluminate concrete with lightweight aggregate of high carbon content and refractory blocks are highly fire resistant materials. Therefore their use in the construction of live fire training structures is highly recommended.

The use of steel in the construction of a burn building must be such that its installation provides an allowance for the expansion and contraction of the steel members as they are heated and cooled by the hose streams. Also the steel reinforcement in concrete would have to be provided with an additional coverage to reduce spalling which may occur as a result of the continuous expansion and contraction of the steel. It is recommended that the surface or external material of the building be a hard and durable material such as concrete or asphalt (Cote, 2003).

2.6.1.3 Design Elements of Burn Buildings

a) Windows for Burn Buildings

It is important to provide as many windows as possible for ventilation. The use of heavy shutters for the windows is necessary to limit the transmission of light into the building. This helps to properly simulate night fire scenarios and reduce low visibility in heavy smoke. Window sills need to be constructed with heavy well treated wood to be able to absorb the force it is subjected to when ladders are used in firefighting drills (Cote, 2003).

b) Roofs for Burn Buildings

The incorporation of multiple pitched roofs as well as flat roofs into the design of live fire training buildings provides trainees with the opportunity to practise with the different types of roofs they may encounter in their line of duty. These roof pitches could have removable panels as illustrated in Figure 2.2 which firefighters could use for ventilation procedures (Cote, 2003).

Figure 2.2: Roof of burn building with removable ventilation panels (Source: Berks County Fire Training Centre, 2008)

2.6.2 Drill/Training Tower

Cote (2003) states that "Perhaps, the single most important element that is included in a fire training facility is a training tower". The provision of a drill tower in a firefighting training school is primarily to equip firefighting trainees with basic drills which involve the use of ladder equipment and pumpers. Secondly, its purpose is to improve their ability to work at various heights in a skilled manner (Elmore, 2001). This confirms the importance of the drill tower to the training of firefighters and its inclusion in a fire training facility cannot be compromised.

According to NFPA (2001), the height of the training tower should be characteristic of the buildings found in the locality of the training facility. However, with the projection of future community development, a much higher height may be considered. Design of the tower should reflect conditions found in the area that the facility serves (Cote, 2003). The height of the training tower as confirmed by both the NFPA (2001) and Cote (2003) must conform to the heights of the existing buildings in the town or city. This enables firefighters to practise at the same building heights as those they may be confronted with later on in their careers.

2.6.2.1 Layout of Drill/Training Towers

The drill tower should have a floor area of at least $36m^2$ (6m x 6m). This dimension must include interior stairwell openings. Although a square configuration may be easier to construct, a rectangular design would allow the inclusion of an enclosed stairway and fire escape which would serve as an alternative access point. The rectangular configuration has an added advantage of providing more internal floor area for stretching hose practice as illustrated in Figure 2.3 (NFPA, 2001). It is essential to design the layout of the tower such that it can easily be configured to simulate the various possibilities of fire outbreak scenarios. Interior rooms, balconies, different types of stairways, fire escape routes and various types of roofs (both pitched and flat) need to be provided. Ideally, the area around the training tower has to be kept clear and open for an area of 30.5m to 61m in as many directions as possible. This is purposely to allow easy maneuvering of vehicles (Cote, 2003). The flexibility in the layout of the drill tower provides trainees with numerous and diverse firefighting scenarios to practise with. This could be achieved with the use of moveable partition walls which can easily be rearranged to depict different situations of fire outbreaks.

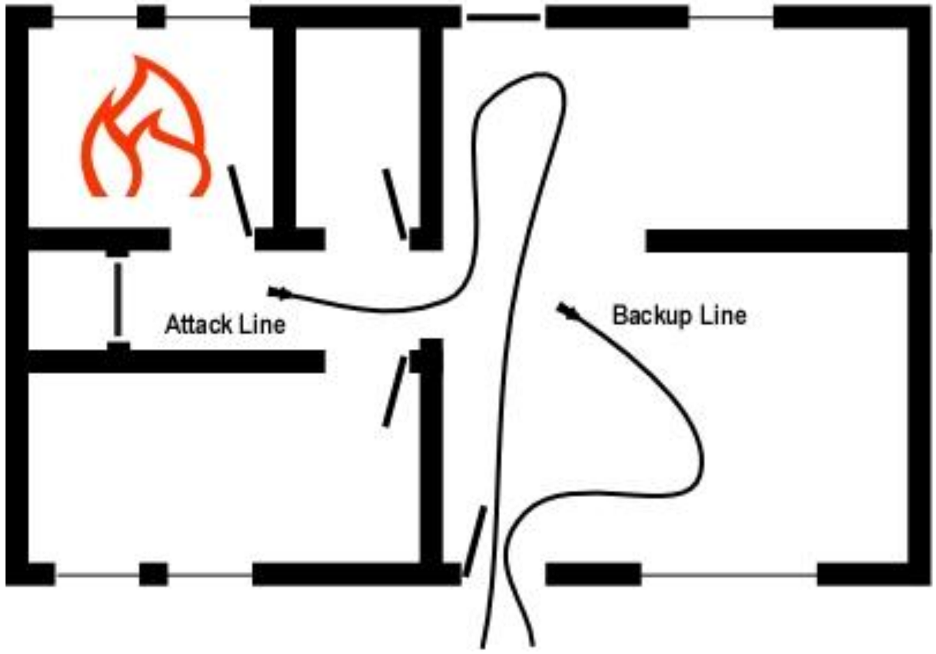


Figure 2.3: Typical floor plan of a drill tower (Source: Mion, 2008)

2.6.2.2 Materials for the construction of Drill/Training Towers

Training towers are non-insulated and non-heated buildings. The material used for its construction is mostly concrete as it best prevents deterioration of the building (Mion, 2008).

2.6.2.3 Design Elements of Drill/Training Towers

The elements employed in the design of drill/training towers include stairways, exterior openings, fire escapes and roofs. These design elements are discussed below.

a) Stairways of Drill Towers

It is necessary to provide either interior or exterior stairways, or a combination of both in a drill tower. Stairways should be located to maximize the available interior floor area. The treads of the stairs have to be slip resistant; open grate treads can prevent the accumulation of water. Stair landings must be wide enough to facilitate easy circulation of firefighters and movement of equipment (Elmore, 2001). In cases where exterior stairways are used, guard rails must be provided to ensure the safety of trainees (NFPA, 2001).

b) Exterior Openings for Drill Towers

All door and window openings should be fully framed and located to simulate situations existing in the field. Heavy wooden sills should be installed to accommodate rope and ladder evolutions (Elmore, 2001). A variety of window types are to be provided in the drill tower. The sills of these windows must be made of heavy wood of a thickness of at least one inch to be able to absorb the impact of rope and ladder drills (Cote, 2003). Both Elmore (2001) and Cote (2003) dwell on the use of heavy wooden window sills to be able to provide a solid anchor for rope and ladder drills.

c) Fire Escapes for Drill Towers

The drill tower can have fire escape configurations placed in them. Railings for these fire escape stairs must be high enough to safeguard a firefighting trainee who is operating a charged hose line on the fire escape (Elmore, 2001).

d) Roofs of Drill/Training Towers

Roof openings are to be provided for the practice of roof ventilation procedures. Openings of various sizes would have to be incorporated in the design on flat and sloped roof surfaces (Elmore, 2001). Equipping the roof surfaces with 4 x 8 ft (1.2 x 2.4m) replaceable sections provides a platform to practise ventilation (Cote, 2003). In cases where the drill tower is not roofed, the topmost section of the roof would have to be fitted with a coping (NFPA, 2001).

2.6.3 Smoke Building

The function of the smoke building in a firefighting training centre is to acquaint the trainees with the skills and abilities necessary in smoke-filled atmospheres/environments. Below is the discussion on its layout and design elements.

2.6.3.1 Layout of Smoke Buildings

The design of the smoke building must be flexible enough to allow for the creation of various internal arrangements to depict various situations under which fire outbreaks can occur. The use of modules that can quickly change can be employed in the design (Elmore, 2001). The smoke building must have entry/exit points and escape hatches at frequent intervals as illustrated in Figure 2.4 in case of an emergency (NFPA, 2001).

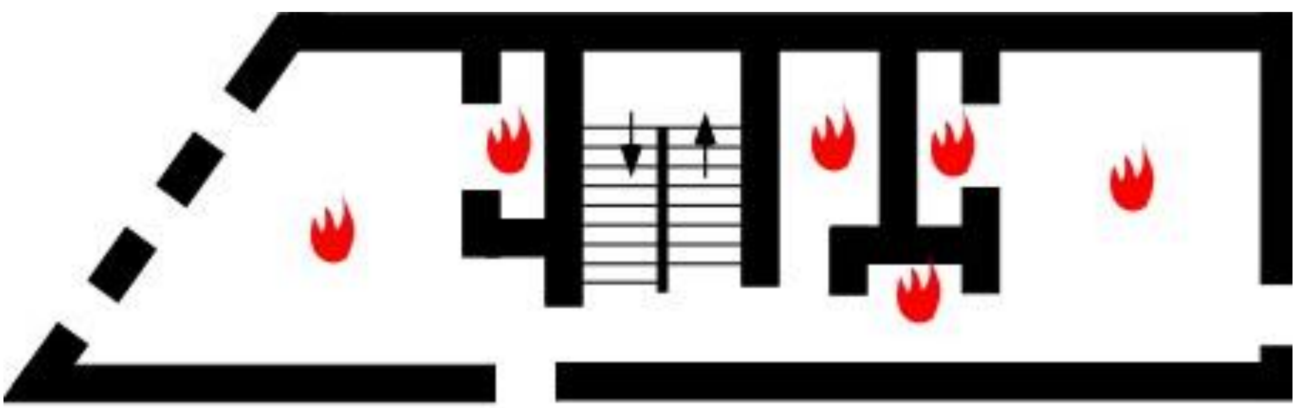


Figure 2.4: Typical floor plan of a smoke building (Source: Mion, 2008).

2.6.3.2 Design elements of Smoke Buildings

Smoke rooms can have sensors built into the floor that indicate the location of the trainees at all times. Ventilation systems are necessary to quickly redirect the smoke being introduced into the building. This can be achieved by the use of blowers or exhaust fans (Elmore, 2001).

2.6.4 Multi-purpose Drill Building

The Guide to Building Fire Training Centres, NFPA (2001) states that, in some training facilities, individual structures for ladder evolutions, fire, or smoke training may not be built due to lack of space or funds. In such instances, a combination building which incorporates all the required functions in one structure would have to be constructed. Consideration should be given to the detrimental effects that any single function can have on the facility, equipment, or other functions. Certain combinations of functions are by their nature more compatible than others. For instance, training activities which involve the use of live fire and smoke are compatible. Consideration must be given to combining all functions, excluding actual fires because the fire function usually results in faster than normal deterioration of the facility. If adequate protection from water and smoke damage is provided, classroom facilities can be combined with the drill tower and smoke function. Other combinations are possible, depending on which functions are required (NFPA, 2001).

2.6.5 Fire Stations

Generally, a fire station supports the needs of the fire department and the community in which it is located. A fire station has extremely diverse functions and its design should be able to accommodate all these functions which include: administration, training, recreation, housing, community education, equipment and vehicle storage, equipment and vehicle maintenance and hazardous materials storage. The design of fire stations usually vary from one station to the other as the design is based on the specific missions carried out by the individual stations, that is the kind of emergency that will be responded to which is directly linked to the location of the facility and the size of the firefighting apparatus. For instance, in an airport, a fire station will be sited adjacent to the runways as they are meant to provide fire protection to the aircrafts. A fire station should be located such that it improves the response time to distress calls so as to be able to bring fire outbreaks under control (Mion, 2008).

2.6.5.1 Spatial Requirements of Fire Stations

Mion (2008) states that the typical functional areas within a fire station must include the apparatus bay, (the main storage area for firefighting and emergency response vehicles), the apparatus bay support area and vehicle maintenance area which are industrial spaces where firefighting vehicles (fire tenders) as well as other equipment used in fighting fire are cleaned, maintained and stored. The rest are administrative and training areas (which comprise office spaces, dispatch facilities, training and conference rooms) and residential areas made up of dormitories, day rooms, kitchen, and residential support areas such as washrooms and fitness spaces.

According to Mion (2008), there are two main primary considerations regarding the functional layout in a fire station. These are as follows:

1. ensuring that internal response times (time within which a firefighter can reach his apparatus and get ready to depart) can be met and
2. separating the areas whose functions are conflicting, such as industrial maintenance spaces and residential spaces.

From Figure 2.5 below, the apparatus bay is located between the maintenance and support areas, the administrative area and the residential (dormitory area, day room, bathrooms and outdoor) areas. This provides a realistic functional relationship within the facility since the apparatus bay is common to both areas. From the administrative and residential areas, where firefighters are usually on stand-by, accessibility to the apparatus bay is direct and this in turn affects the response time (increases response time). The fire tenders are also easily accessible when maintenance works are to be carried out on them. The layout also creates room for expansion (after the maintenance area) of the apparatus bay when the need arises. However, the internal response times should still be met after the expansion and thus care should be taken if any such design decisions are taken (Mion, 2008).

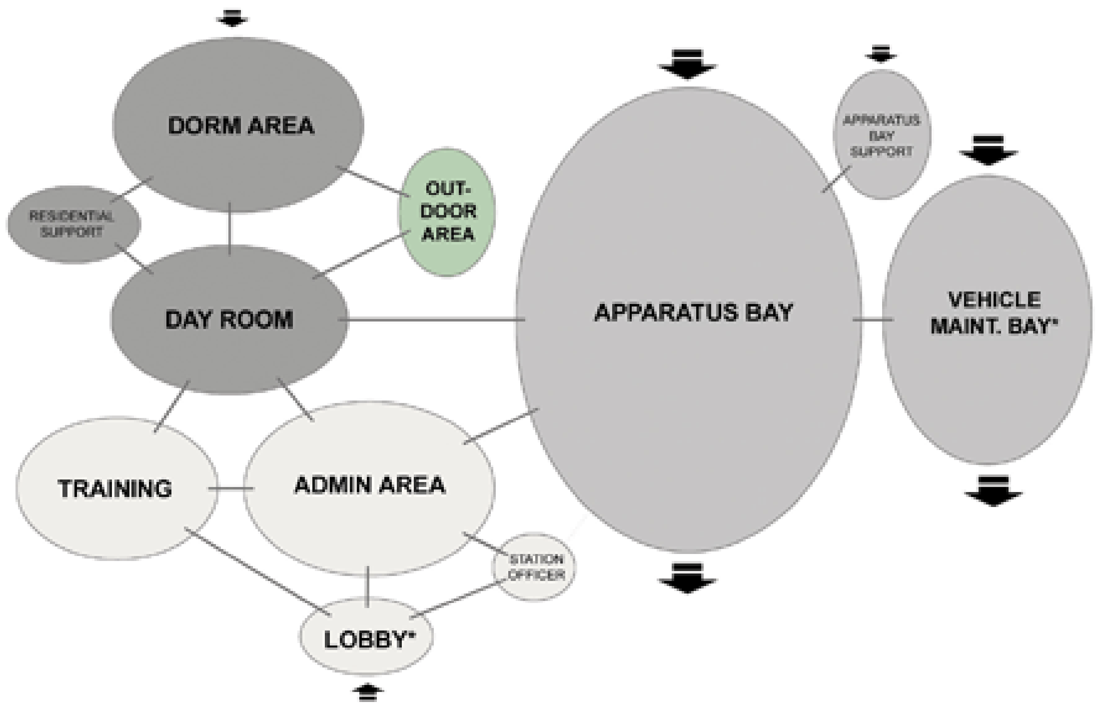
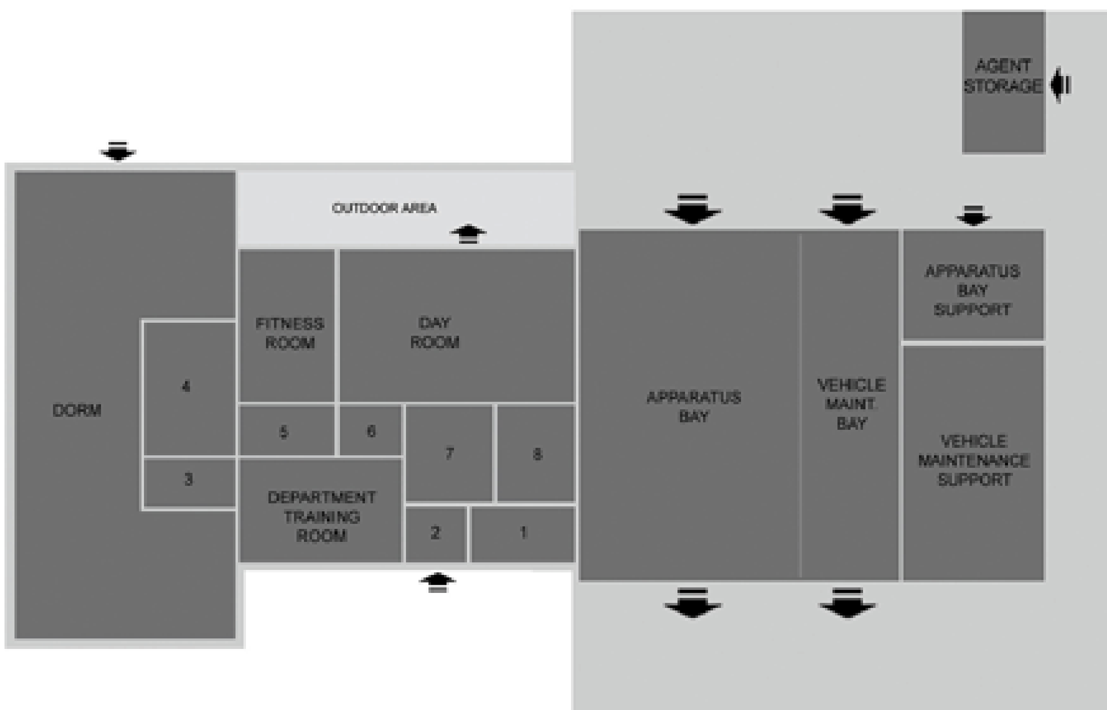


Figure 2.5: Adjacency diagram for a fire station (Source: Mion, 2008)

In firefighting, increasing the response time is very critical as this has a direct effect on the result (damage to lives and property or otherwise) of a fire outbreak. As such, every attempt must be made to ensure that the speed with which firefighters reach the scenes of fire outbreaks is increased immensely. A fire station located on the premises of a firefighting training centre is no exception since in this case, it is the main teaching aid when it comes to response to fire.

Therefore, ensuring that its spatial arrangement and its physical location within the training facility denotes speed is essential. Ideally, the entire size of the apparatus bay should be based on the largest vehicle in the fleet or the largest anticipated vehicle. Apparatus bays are typically drive-through bays but in situations where doors are required for one reason or the other, the doors must be wide enough to accommodate the largest vehicle and must also be manually operational in case of power failure. Having a drive-through apparatus also improves the efficiency of firefighters as there are no obstacles to impede the movement of fire tenders during emergencies (Mion, 2008).



1. Station officer's office / watch desk
2. Lobby
3. Laundry room
4. Bathrooms/ showers/ changing room
5. Computer testing/ training room
6. Training officer's office
7. Administration
8. Emergency Operation Centre

Figure 2.6: Functional layout for a fire station (Source: Mion, 2008)

2.6.5.2 Design Considerations for Fire Stations

Key design goals and considerations for fire stations include the following: the promotion of the quality of life of the occupants (24- hour firefighting personnel), ensuring good indoor air quality and ventilation of industrial spaces and the provision of ample recreation areas, separating noisy areas such as game rooms from quieter areas such as television rooms (Mion, 2008).

2. 7 FIRE SAFETY IN FIREFIGHTING TRAINING CENTRES

The issue of fire safety cannot be overlooked in a facility such as a firefighting training centre. Due to the use of live fire for training, the probability of fire outbreaks is very high. Appropriate fire safety measures must therefore be put in place to prevent such incidents. According to the International Building Code (2006), every building shall be designed and constructed so as to:

1. Inhibit the spread of fire to nearby buildings by dividing the building into compartments.
2. Provide adequate resistance to the spread of fire and smoke by the provision of different uses in a building by means of compartment walls and floors and the separation of the building from any adjoining building or site.
3. Maintain the structural stability of the building in case of fire.
4. Provide adequate resistance to the spread of fire over the roof of one building to another.

Building Regulations 2000 (2004), Approved Document B “Fire Safety” B2 Requirement states that to inhibit the spread of fire within a building, the internal linings (materials used in lining any partition, wall, ceiling or other internal structures) shall adequately resist the spread of flame over their surfaces and have if ignited, a slow rate of heat release. The choice of materials for walls and ceilings can significantly affect the spread of fire and its rate of growth. Several properties of a lining material including its ease of ignition and the rate at which it gives off heat when burning influence fire spread in a building. All load bearing walls must have a minimum standard of fire resistance to prevent the structure from collapse in case of fire. Compartmentation, a subdivision of the building into various compartments, can restrict the spread of fire. This separation can be done using walls and floors of fire resistive construction (Building Regulations, 2004). Both active and passive systems of fire protection can also be employed as measures of fire safety in a fire training centre.

2.7.1 Passive Fire Protection Systems

Passive fire protection is defined by Wikipedia (2008) as an integral part of structural fire protection and fire safety in a building. Passive fire protection aims at containing or slowing the spread of fire through a building through the use of fire rated assemblies. Fire rated assemblies generally refer to the various parts of a building which are designed to inhibit the spread of fire and they include fire resistant walls, floors, windows and doors (Wikipedia, 2008).

2.7.1.1 Fire walls

Wikipedia (2008) defines a fire wall as a structurally stable and fire resistant wall which separates or subdivides a building to prevent the spread of fire. A fire wall could therefore be described as one of a building's passive fire protection systems. Fire walls are usually partitions, which by nature of their construction and certification status are guaranteed to resist a cellulosic or hydrocarbon fire test for a particular time and period and are able to withstand structural collapse on either side and remain standing. Fire walls which are provided with fire-resistance ratings to standardized fire exposures and fire test requirements are used in burn buildings to prevent the spread of live fire being simulated for training purposes to surrounding structures.

2.7.1.2 Fire Rated Door Assembly

This consists of any combination of a fire door, a frame, and other accessories that together provide a specific degree of fire protection to the opening in which the door is placed. They are mostly given hourly fire ratings. Fire doors that have 20-30 minute fire resistant ratings are primarily provided for smoke control and are therefore normally provided in fire partitions of ratings up to one hour and along corridors where smoke control is required (Wikipedia, 2008).

2.7.1.3 Fire Windows

These are windows designed to protect openings in exterior walls, that is, the main function of the fire window is to contain the flames from fire being used for training within the burn building (Wikipedia, 2008).

2.7.2 Active Fire Protection Systems

These are design elements of mechanical, electrical and plumbing features which aid in fire detection and fighting. They include smoke detectors, automatic sprinkler systems and portable fire extinguishers.

2.8. CASE STUDY OF BERKS COUNTY FIRE TRAINING CENTRE

The Berks County Fire Training Centre is located in Pennsylvania in the United States of America. This particular facility is studied to acquire a detailed insight into the various components in the training centre with special attention to the materials and design elements utilized.

2.8.1 Facilities of the Berks County Fire Training Centre

The facilities available at the Berks County Fire Training Centre include the administration building, the drill tower, the live fire burn building, the bulk flammable liquids pit and the confined space tank. Others are the drafting pit, the extinguisher pit, the gasoline and acid tanker and the smoke maze.

a) Administration Building

The administration building offers a state-of-the-art educational facility that allows students to learn and educators to utilize the latest technology to convey knowledge. The building offers four individual classrooms, each with a television set, overhead projector, sound system, laptop, LCD projector, document camera and slide projector. With the modular format utilized in the classrooms, the four individual classrooms can be combined into one large classroom which allows for seating of 100 students with tables or over 150 students with chairs only.

Figure 2.7: The administration building (Source: Berks County Fire Training Centre, 2008)

A detailed list of the sizes of the classrooms, the capacity and the equipment used are shown in Table 2.1 below.

Table 2.1: Sizes of classrooms, capacity and equipment of the Berks County Fire Training Centre (Source: Berks County Fire Training Centre, 2008)

CLASSROOM	**SIZE**	**SEATING**	**EQUIPMENT**
A	25' x 29' = 725 Sq. Ft.	30 with tables	Laptop, LCD Projector, Document , Camera, Sound System, TV & VCR, Overhead Projector, Whiteboard
B	24' x 23' = 552 Sq. Ft.	20 with tables	Laptop, LCD Projector, Document , Camera, Sound System, TV & VCR, Overhead Projector, Whiteboard
C	24' x 24' = 576 Sq. Ft.	24 with tables	TV & VCR, Overhead Projector, Whiteboard
D	25' x 29' = 725 Sq. Ft.	27 with tables	Laptop, LCD Projector, Document , Camera, Sound System, TV & VCR, Overhead Projector, Whiteboard
Lunchroom	54' x 29' = 1566 Sq. Ft.	64 with tables 100 chairs	TV & VCR, Overhead Projector, Slide Projector
Combined Classroom (Created by opening walls to small classrooms	58' x 49' = 2842 Sq. Ft.	100 with tables 150 chairs	Laptop, LCD Projector, Document , Camera, Sound System, TV & VCR, Overhead Projector, Whiteboard

b) The Drill Tower

The five storey drill tower is equipped with a fire escape, a standpipe and sprinkler system, a fire alarm panel and balconies. Simulated electrical lines to the north of the building are used in training sessions such as the raising of ladders and the operation of apparatus near electrical equipment (Berks County Fire Training Centre, 2008).

Figure 2.8: Drill tower (Source: Berks County Fire Training Centre, 2008)

c) Live Fire Burn Building

The burn building consists of two structures attached to each other. The eastern structure is a three storey row home whereas the western structure is a four storey commercial/industrial structure. The row home is detailed to match as closely as possible a real single family end of row structure. It has two burn rooms in the basement, three on the first floor, with three and two burn rooms on the second and third floors respectively. The roof has a 4 x 4 feet cut out to allow trainees to vertically ventilate the attic (Berks County Fire Training Centre, 2008).

Figure 2.9: Roof ventilation panels (Source: Berks County Fire Training Centre, 2008)

The commercial/industrial building has a different floor layout on each of the five levels. The floors are designed to closely simulate real live fire attack problems encountered in similarly sized buildings (Berks County Fire Training Centre, 2008).

Figure 2.10: The live fire burn building (Source: Berks County Fire Training Centre, 2008)

A modified sprinkler system has been created on the second floor to allow the trainees to conduct operations with a sprinkler contained fire. The roof of the building has a large combustible roof simulator. The windows and doors of both structures consist of steel plate components for durability (Berks County Fire Training Centre, 2008).

Figure 2.11: Burn building showing steel windows (Source: Berks County Fire Training Centre, 2008)

d)Bulk Flammable Liquids Pit

This evolution area consists of two (2) pits: an 18 feet diameter round pit and a rectangular pit measuring 20 x 40 feet with a 20 x 20 feet "leg" forming "L" shaped pit. There is also a two storey control tower located to the north of the evolution area. The bulk flammable liquids pit is a location where gasoline or other volatile or flammable liquids are stored and from which such products are distributed (Berks County Fire Training Centre, 2008).

Figure 2.12: Flammable liquids pit (Source: Berks County Fire Training Centre, 2008)

e) Confined Space Tank

This training area consists of a 10,000 gallon tank with a narrow walkway for access to vertical and horizontal openings. This area is designed to allow trainees to enter a confined space by a vertical or horizontal opening. A chlorine rail car dome has been attached to the top of the tank to allow students to simulate the containment of a chlorine leak from the dome of a rail car (Berks County Fire Training Centre, 2008).

Figure 2.13: Confined space tank (Source: Berks County Fire Training Centre, 2008)

f) Drafting Pit

The drafting pit is a concrete pit which can be used to simulate drafting operations. Drafting is the use of suction to move a liquid such as water from a container or a water body below the intake of a suction pump. The suction pump creates a partial vacuum (a draft) and the action of the atmospheric pressure on the surface of the water forces the water to pump (Wikipedia, 2008).

Figure 2.14: Drafting pit (Source: Berks County Fire Training Centre, 2008)

g) Extinguisher Pit

The extinguisher pit training area is made up of a rectangular containment pit with various sizes and shapes of small pans and a flammable liquids cabinet. It is used for drills involving portable fire extinguishers (Berks County Fire Training Centre, 2008).

Figure 2.15: Extinguisher pit (Source: Berks County Fire Training Centre, 2008)

h) Gasoline and Acid Tankers

This area which is designed to be used for diverting spills or as a realistic target for foam application consists of a five compartment gasoline tanker rolled on its side. It also has an acid tanker for training sessions involving acids (Berks County Fire Training Centre, 2008).

Figure 2.16: Gasoline and acid tankers (Source: Berks County Fire Training Centre, 2008)

i) Smoke Maze

The old burn building, no longer useful to conduct live fire training, has been enhanced to serve as a smoke maze (Berks County Fire Training Centre, 2008).

Figure 2.17: Smoke maze (Source: Berks County Fire Training Centre, 2008)

2.8.2 Materials used in the Construction of the Burn Building at Berks County Fire Training Centre

Figures 2.18 to 2.21 show a photographic documentation of the construction process of the burn building at the Berks County Fire Training Centre. It illustrates the materials required for the construction of the burn building which is predominantly concrete and steel.

Figure 2.18: Steel framework for the foundation of the burn building (Source: Berks County Fire Training Centre, 2008)

Figure 2.19: Casting of ground concrete floor slab (Source: Berks County Fire Training Centre, 2008)

Figure 2.20: Erection of concrete walls reinforced with steel (Source: Berks County Fire Training Centre, 2008)

Figure 2.21: Concrete slabs used for the walls and ceilings of the burn building (Source: Berks County Fire Training Centre, 2008)

2.8.3 Conclusions on Berks County Fire Training Centre

The provision of various facilities such as the live fire training building, the drill tower and the smoke maze provides the platform for the different training sessions such as live fire drills, ladder and rope drills and breathing apparatus drills respectively. The use of the appropriate building materials, mostly concrete and steel which are high fire resistive materials in the construction of the various components will prolong the longevity of the buildings.

2.9 CONCLUSIONS TO LITERATURE REVIEW

In conclusion, this chapter defines the standard components of a firefighting training centre, specifically dwelling on the provision of outside facilities which include the live fire training (or burn building), the drill tower and the smoke building. The existence of these buildings cannot be over emphasized since they are the main structures used to practically equip firefighters to deal with real fire outbreaks. Since these buildings, especially the burn building, are continuously exposed to live fires, it is necessary to use fire resistant materials such as masonry, reinforced concrete, calcium aluminate concrete, refractory blocks and steel liners in their construction. The use of such materials will help reduce the rapid deterioration of the buildings, thus prolonging their use for their specific functions. It is also appropriate to use 'all- weather' materials such as concrete in the drill areas since these areas will be subjected to a lot of vigorous activities, including live fire drills. The use of such materials will help reduce wear and tear of the surface, thus prolonging its use for its function.

Apart from these structural buildings which are mainly used in the practical aspect of training, other facilities which assist in the theoretical aspect of the training must be provided. These include classrooms where all the theory of firefighting would be imparted, an administration which will manage the affairs of the school, a library to fully resource students, a fire station which will serve as both a teaching aid and an operational fire station and a vehicle maintenance unit where the fire tenders will be serviced. Also the assertion made about the interconnection of all road networks within the facility is to facilitate easy access to all buildings and drill areas in the school. To prevent congestion and to allow the free flow of traffic into and out of the training centre, the facility must have various routes from different directions with gates provided at these entrances and exit points to check security as well.

CHAPTER THREE: RESEARCH METHODOLOGY

This section explains the methodology through which data was collected. It also outlines the methods employed in the collection and analysis of the data.

3.1 SOURCES OF DATA

Both primary and secondary sources of data were employed in the research work. The primary sources of data included interviews and observational field notes and photographs. The secondary sources of data were from both the library and the e-library (internet) which included books, journals, reports, conference papers, periodicals and research projects.

3.1.1 Interviews

Some officials of the Ghana National Fire Service and the Ghana Police Service were contacted to ascertain some facts relevant to this thesis. This included an extensive interview with the Head of Training at the Ghana National Fire Service (GNFS) Headquarters in Accra to acquire details concerning the training of fire fighters. The commandant and seven (7) out of the fifteen (15) instructors of the Fire Academy and Training School (FATS), located at James Town, Accra were interviewed to have an insight into the training of fire personnel as well as facilities needed to fully equip them for their duties. Interviews were also conducted among thirty (30) senior fire officers to have an idea of the daily activities of a firefighter. The Public Relations Officer of the Ashanti Regional Headquarters of the GNFS was also contacted to acquire some information on the operation of the Service in the country. The Head of Training at the Ghana National Police Training School located at Tesano, Accra was also interviewed.

3.1.2 Field Survey

The Fire Academy and Training School, James Town, Accra was visited to observe the various facilities available, activities being carried out as well as the general layout of the training centre. Physical measurements of the drill yard were taken. Photographs of the various facilities were documented by means of a digital camera. The suitability and feasibility of the site were determined through a reconnaissance survey which was conducted on the site. Photographs of the site were documented.

3.1.3 Case Studies

Both local and foreign facilities of the same or similar functions were studied. These were the Fire Academy and Training School located in James Town, Accra and the Berks County Fire Training Centre, Pennsylvania. Both facilities were analyzed and conclusions were drawn after the study to aid in the thesis.

3.2 ANALYSIS

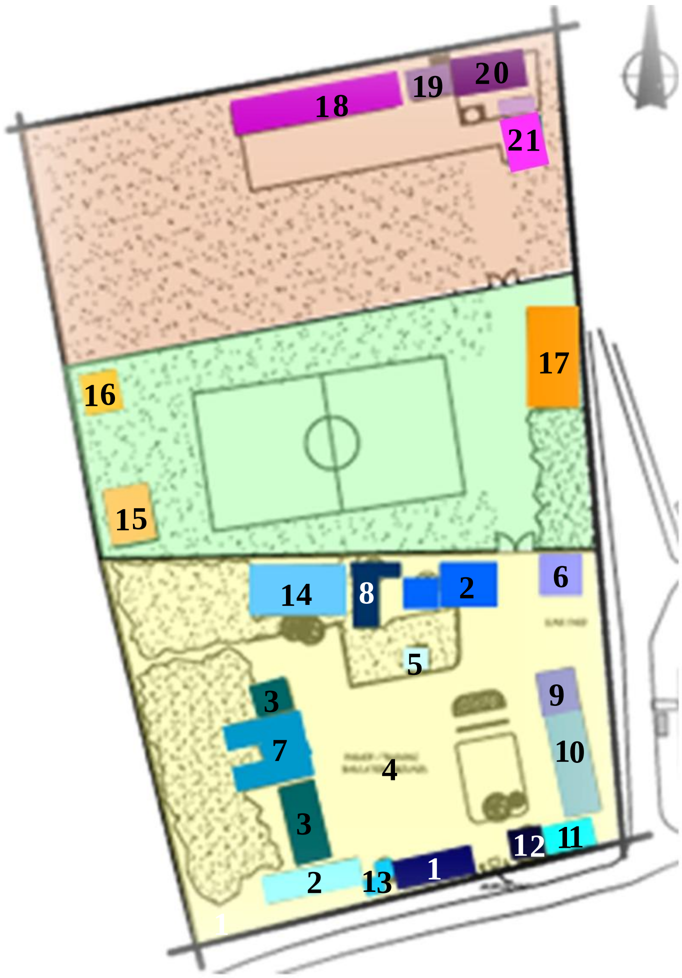
The information obtained was analyzed using the descriptive method between existing situations (case studies) and the standards and requirements reviewed in the literature in the previous chapter. A new firefighting training school was then designed with each of the design decisions and facilities included as compared with the standards and requirements from literature. The guide, conclusions and recommendations were then given.

CHAPTER FOUR: FINDINGS AND DISCUSSIONS

This chapter deals with the analysis of the findings from literature and a case study of the Fire Academy and Training School in Accra to help design a model firefighting training facility in Ghana. Details in terms of the location, components (both basic and specialized facilities), materials used, circulation patterns, lighting, ventilation and fire safety measures employed in the design of the proposed model firefighting training centre are discussed.

4.1 FIRE ACADEMY AND TRAINING SCHOOL

The Fire Academy and Training School (FATS) is situated along the Old Winneba Road, at James Town in Accra. It is bounded on the north by the Korle-Bu-Accra Road, on the south by the Old Winneba Road and the Gulf of Guinea, on the west by the Korle Lagoon and on the east by the James Town township. This facility, which is the only training facility for firefighters in Ghana currently admits a total number of 250 to 300 recruits per training which covers a period of six (6) months. Officer Cadets are also trained for a period of nine (9) months. The school was however not purposely designed for its current use since the premises on which they operate was given out to the Ghana National Fire Service after having served as a warehouse for Mobil Ghana for a while. As such, most of the structures currently in the school do not meet the standards required for a firefighting training facility as stated by literature. Figure 4.1 below illustrates the site layout of the Fire Academy and Training School at James Town, Accra.



1. Administration block
2. Instructors' offices
3. Classroom block
4. Drill yard parade grounds
5. Drill hose tower
6. Smoke chamber
7. Senior officers' mess
8. Projects department
9. Paramedical centre
10. Central mechanical workshop
11. Central stores
12. Fire station
13. Carport
14. Junior officers, mess
15. Church
16. Mosque
17. Instructors' flats
18. Male dormitory
19. Dining hall
20. Female dormitory
21. Boys' bath house

Figure 4.1: Site layout of the Fire Academy and Training School in Ghana

The Fire Academy and Training School is zoned into three main areas namely:

1. The educational zone

2. The recreational/religious zone

3. The accommodation zone

4.1.1 Facilities at the Fire Academy and Training School

The main facilities which constitute the educational zone are: the main administration block, junior instructors' administration block, classroom block, drill yard, drill/hose tower and the smoke chamber. The rest are the senior officers’ mess, projects department, paramedical centre, central mechanical workshop, central stores and a sub-fire station.

4.1.1.1 Main Administration Block

The administration block consists of the control room, the exchange room, the commandant’s office, the deputy commandant’s office, the general administrative office, accounts office, director of studies’ office, senior officer’s common room, a library, the National Ambulance Service control room, a store (for the school), a store keeper’s office and sanitary facilities.

Figure 4.2: Front view of the main administration block

4.1.1.2 Junior Instructors’ Administration Block

This block comprises the following: chief drill instructor’s office, junior instructors' study room and a senior instructors’ study room.

4.1.1.3 Classroom Block

There are a total of six (6) classrooms each measuring approximately 5m x 7m. Each classroom has an average of thirty-five (35) students. Apart from their relatively small sizes, the classrooms are not adequately equipped for minor indoor hands-on training activities. As such, their proximity to the drill yard is advantageous since these minor training activities can be carried out there.

Figure 4.3: Classroom block

4.1.1.4 Drill yard/Parade grounds

The drill yard, which is the main yard for the practical aspect of the training, also doubles up as parade grounds for ceremonial purposes. It is rectangular in shape, measuring approximately, 100m x 80m as shown in Figure 4.4. The area of the drill yard is substantial enough for its dual purposes either simultaneously or at different times.

Figure 4.4: Drill yard /parade grounds

4.1.1.5 Drill / Hose Tower

The drill tower which is a five (5) storey structure is located on the northern end of the drill yard as shown in Figure 4.5. It has open interior staircases which are well lit for training purposes. The structure also has honey comb walls for ventilation as well as lighting. The hose tower is used for ladder drills and knot and line drills. It is also used to drain the hose which has a standard length of 75 feet.

Figure 4.5: Drill tower

4.1.1.6 Smoke Chamber

The smoke chamber is used for smoke related simulations and training activities. It is also utilized for live fire training activities since no provision is made for a burn building in the school. As shown in Figure 4.6, the smoke building has deteriorated due to the intense heat it has been subjected to over the years. This is due to the fact that sandcrete blocks which are not high fire resistant materials were used in its construction.

Figure 4.6: Smoke chamber

4.1.1.7 Senior Officers' Mess

This includes the following facilities: two large multi-purpose halls, a TV room, a bar, dining area, a kitchen, store room, an administrator's office and sanitary facilities.

Figure 4.7: Exterior and interior views of the senior officers' mess

4.1.1.8 Projects Department

This department takes up renovation works and the general maintenance of the facility. It has an administration and consists of draftsmen, plumbers, carpenters, electricians, masons and steel benders.

4.1.1.9 Paramedical Centre

The paramedical centre consists of an out-patient department, (OPD), a pharmacy (with a pharmacist and his assistant), a consulting room, matron's office, recovery ward, an ambulance bay and an administrator's office. The wards can accommodate a total number of four officers which is insufficient compared to the number of recruits, instructors and support staff and most importantly, the high risk of accidents associated with firefighting training.

Figure 4.8: The paramedical centre showing views of the OPD and the ward.

4.1.1.10 Central Mechanical Workshop

This maintenance department services all fire appliances in Ghana. With a total floor area of approximately 192m^2, the workshop consists of four bays (each bay measuring 6m x 8m) for damaged vehicles. When all four bays are occupied, vehicles waiting to be serviced park directly opposite the workshop. The maintenance department includes the following sections: welding, electrical, refrigeration, mechanics, sign writers as well as type writers. Apart from the overall head of department, there are heads for the various sections of the department.

Figure 4.9: The maintenance department

4.1.1.11 Central stores

The central stores serve as the main storage facility for all fire stations in Ghana. There are five (5) main stores: the stationery store, the spare parts store (for fire tenders and command cars), the clothing store, the expendable store (for food items and building materials) and the equipment store (for hoses, breathing apparatus and foam). There is an office for the head of stores and two for his two deputies, two warehouses mainly for the storage of tyres, foam and hoses.

4.1.1.12 Sub-Fire Station

The sub-fire station consists of the following spaces: a control/ watch room, district fire officer's office, operational fire officer's office, duty fire officer's office, and a crew room.

Figure 4.10: The sub fire station at the school

All of the above mentioned facilities are arranged around the parade grounds/drill yard. The recreational/religious zone consists of a mosque, a church (which is currently under construction), a football field and instructors' flats.

Figure 4.11: The instructors' flats

The accommodation zone is made up of male and female dormitories with sanitary facilities, a dining hall and a pantry.

Figure 4.12: The dining hall and the male dormitory block

4.1.2 Conclusions on Fire Academy and Training School (FATS)

The use of a common space or area to serve dual purposes (drill yard and parade grounds) is an effective way of using the space judiciously since its area (800 square metres) is quite extensive to accommodate both parade and drill activities simultaneously. However, the use of the smoke chamber as a burn building is inappropriate since it is not specifically designed with fire resistant materials such as calcium aluminate concrete, masonry or refractory blocks to withstand the extreme temperatures it is subjected to during live fire simulations. As recommended by Mion (2008), the inclusion of a fire station within the premises of the training centre is a laudable idea because it serves as a teaching aid in the training process as recruits are able to have a firsthand observation of the response time and the speed with which firefighters move. Even though the Fire Academy and Training School consists of the basic components of a firefighting training centre, the available facilities are not properly designed to serve their various purposes. For example, the classrooms are not large enough to perform hands-on training. The absence of a variety of facilities such as special training laboratories, computer laboratories, flammable liquids and gas areas, and a pool for water rescue training does not help in the efficient training of firefighters in Ghana.

4.2 ARCHITECTURAL DESIGN OF THE PROPOSED MODEL FIREFIGHTING TRAINING CENTRE

Based on the findings from the literature review and the case studies, a model architectural design of a firefighting training centre has been developed. The design includes both the basic and specialized facilities required for the efficient training of firefighters in Ghana.

4.2.1 Location of Site

The site is located at Ejisu, about 900m off the Ejisu-Abankro Road in the Ejisu-Juabeng District of the Ashanti Region of Ghana. The site is bounded on three sides (north, west and south) by proposed roads and on the eastern side by a nature reserve as illustrated in Figure 4.13 below.

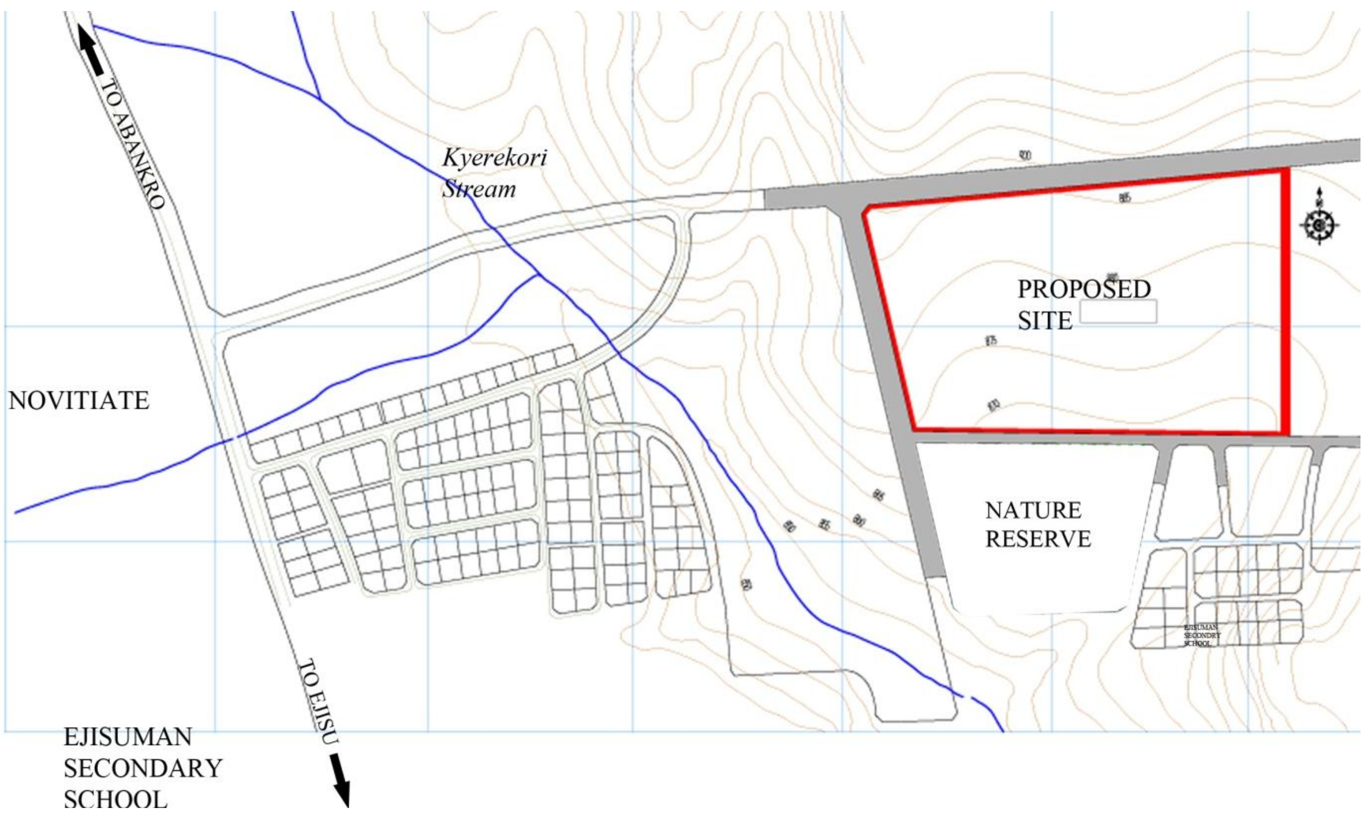


Figure 4.13: Site location map (Source: Ejisu-Juabeng Municipal Assembly, 2008)

4.2.1.1 Justification for the Selected Site

A firefighting training centre as stated by Elmore (2001) should ideally be located in a remote area hence the choice of site in the peri-urban areas of Ejisu, in the Ejisu-Juabeng District of the Ashanti Region of Ghana. The site has an area of approximately 250,000 square metres which is extensive enough to accommodate all the training facilities and its future development and also provide enough grounds for firefighting drills. The site is also close to a stream, the Kyerekori stream where water for fighting fire during training sessions can easily be tapped from. Moreover, firefighting drills, most of which produce smoke, can be undertaken without causing air or noise pollution due to its remote location. The three proposed roads bounding the site would provide multiple options of accessibility to the site.

According to Elmore (2001), the area master plan must be checked to confirm the zoning of land use in the area. A site peripheral study conducted revealed that apart from the sand quarrying activities which is to the northern part of the site and the nature reserve which is to the southern part of the site, the rest of the activities around the site are mostly educational as shown in Figure 4.13. To the west of the site across the Ejisu-Abankro Road is the Spiritan Institute of Philosophy and Novitiate. Further down to the south-western end of the site is a HIPC/GetFund Model School. From the model school towards the Accra-Kumasi road is the Ejisuman Secondary School. These institutions are approximately 1000m, 1200m and 1500m respectively away from the proposed site. This makes the area where the site is located an educationally dominated zone.

4.2.2 Zoning of Site

Based on the case study of the Fire Academy and Training School (FATS) in Accra where the training facility is zoned into areas based on the various activities carried out, the site for the design of the firefighting training school is zoned into four main areas as follows:

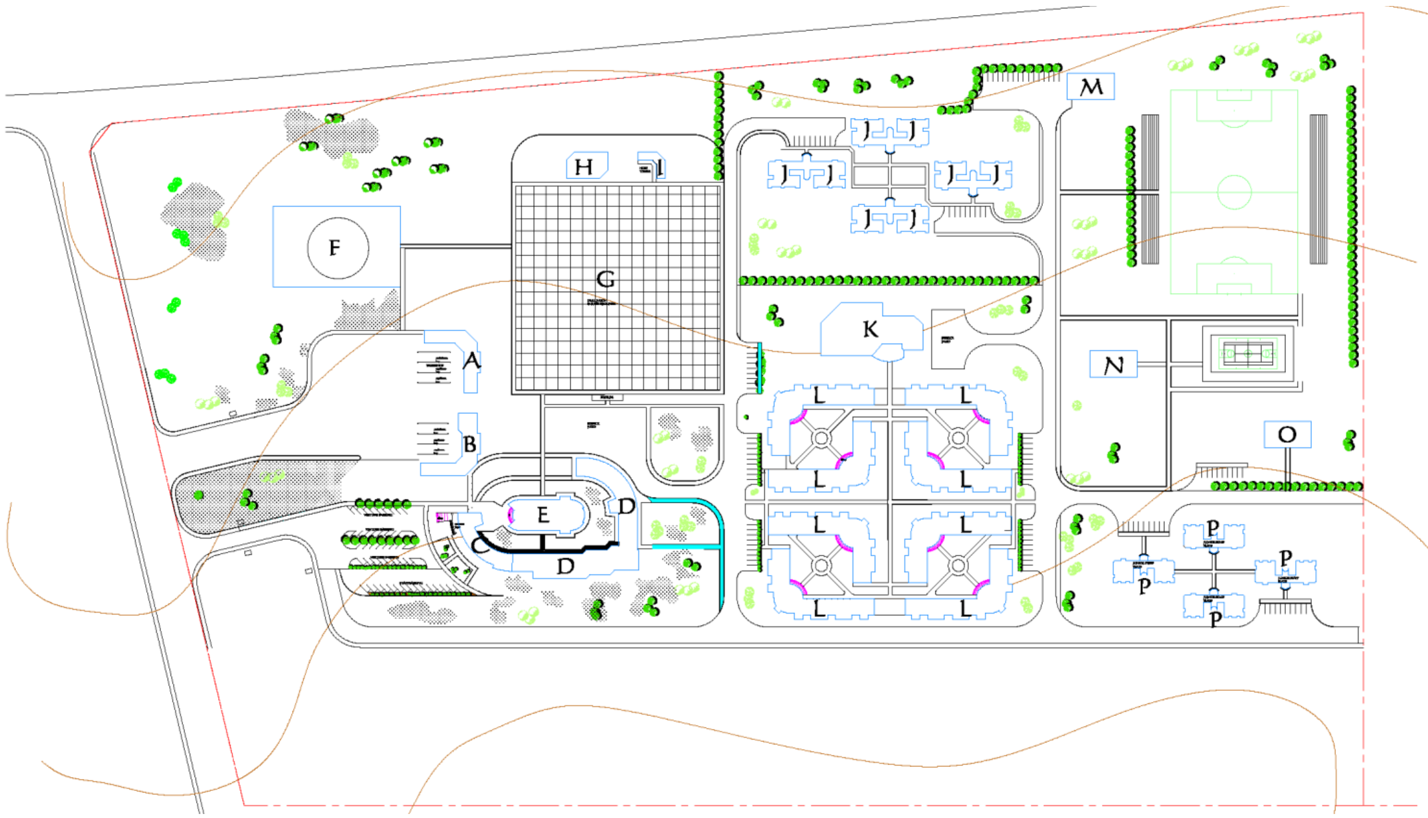
1. The operational zone (consisting of the fire station, the vehicle maintenance unit and the helipad),
2. The training zone (including the lecture rooms, library, laboratories, computer centre, administration block and drill yard),
3. The accommodation zone (staff and students' accommodation) and,
4. The recreational/sports zone.

The above zoning of the site is based on the similarities in function of the various facilities and spaces which improves the efficiency of training as a result of a much more effective functional relationship between all the facilities in a particular zone. It also helps to separate the noisy areas (practical training areas) from the much quiet areas (lecture rooms, library, and accommodation facilities).

4.2.3 Site Layout of the Model Firefighting Training Centre

There are two entry points, both on the western side of the school. Possible access routes to the site were considered and analyzed but the positioning of both the entry and exit points on the western boundary of the site was mainly for security purposes. The first entrance is exclusively for fire tenders and the second, the main entrance to the facility (which also serves as the service access).

The school consists of all the components of a firefighting training centre (administration, classrooms, library, storage and supply, cafeteria, laboratories, dormitory, changing and dressing rooms, structural fire buildings, drill tower, control tower, and maintenance) as substantiated by literature, (NFPA, 2001). In addition to these buildings is the integration of a fully equipped fire station as supported by literature (Mion, 2008). It serves as a teaching aid and at the same time an operational fire station from which firefighters can be discharged to deal with fire outbreaks in the vicinity.



A- Maintenance unit	B- Fire station	C- Administration block	D- Classroom block
E- Multi-purpose hall	F- Helipad	G- Drill yard	H- Burn Building
I- Drill/ hose tower	J- Senior Staff flats	K- Dining hall	L- Students' hostel
M- Senior officers' mess	N- Gymnasium	O- Junior officers' mess	P- Junior officers' flats

Figure 4.14: Site layout

The fire station which is the first building when approaching the school is strategically located to facilitate the speed with which firemen respond to the distress calls. Next to it is the maintenance unit where the fire tenders are easily accessible when the need arises for maintenance works to be carried out on them. Provision is made for the following in the fire station: reception, control room, offices for the station commander, duty officer and fire prevention officer, ambulance service, briefing room, a crew room, locker rooms, staff lounge and sanitary facilities. The administration block mainly houses the teaching staff offices for the administrative duties of the school. The teaching and learning areas comprise a drill yard/parade grounds, lecture rooms, a library, a computer centre (where computer models of various scenarios of fire outbreaks can be simulated and possible ways of extinguishing them researched into) and laboratories.

Apart from the training facilities, provision is made for an officers' mess where firefighting personnel can relax during their leisure hours. Recreational facilities including a gymnasium, a football pitch and a basketball court are provided to see to the fitness of fire personnel. Adequate accommodation for both students and staff as well as a multi-purpose hall are provided. The provision of a helipad with a helicopter provides students with the double opportunity for practical hands-on training of several scenarios involving aircrafts and using the aircraft in firefighting. Its location (close to both the drill yard and the fire station) ensures its efficient use by both firefighting personnel manning the fire station and the trainees. Firefighting drills in automobiles are carried out in an open space next to the area demarcated for the helipad. The area for automobile training is equipped with old cars to simulate car firefighting scenarios as well as car accident rescue scenarios. Firefighters apart from being trained to extinguish fire, offer certain humanitarian services including the rescue of people from car accidents and plane crashes. Thus the inclusion of the automobile training area and the helipad are necessary for the training of firefighters in these areas.

4.3 COMPONENTS AND DESIGN ELEMENTS OF THE PROPOSED MODEL FIREFIGHTING TRAINING CENTRE

The training school is made up of the following components: classroom block (which houses the library, laboratories and a computer centre where computer models of various scenarios of fire outbreaks can be simulated and possible ways of extinguishing them researched into), a drill yard, and an administration block. In addition to these is a fully equipped fire station which serves as a teaching aid and at the same time an operational fire station from which firefighters can be discharged to deal with a fire outbreak in the vicinity. The rest include a maintenance unit, multi-purpose hall, accommodation facilities for students and staff, officers' mess (for both senior and junior members of staff) and recreational facilities which include a football pitch, a basketball court and a gymnasium.

4.3.1 Classrooms

Based on the ideal ratio of firefighters to civilian population, that is 1:800, it is anticipated that a 50% increment in the number of recruits per training period (six months) for six (6) years would make up for the deficiency in the system. Each classroom is therefore designed to take an average number of forty-five (45) students. There are twelve (12) classrooms in all. Full height foldable partition doors (as illustrated in Figure 4.15) are provided to vary the sizes of the classrooms to accommodate large numbers of students (as in the case of a combined class) as supported by literature, (Elmore, 2001).

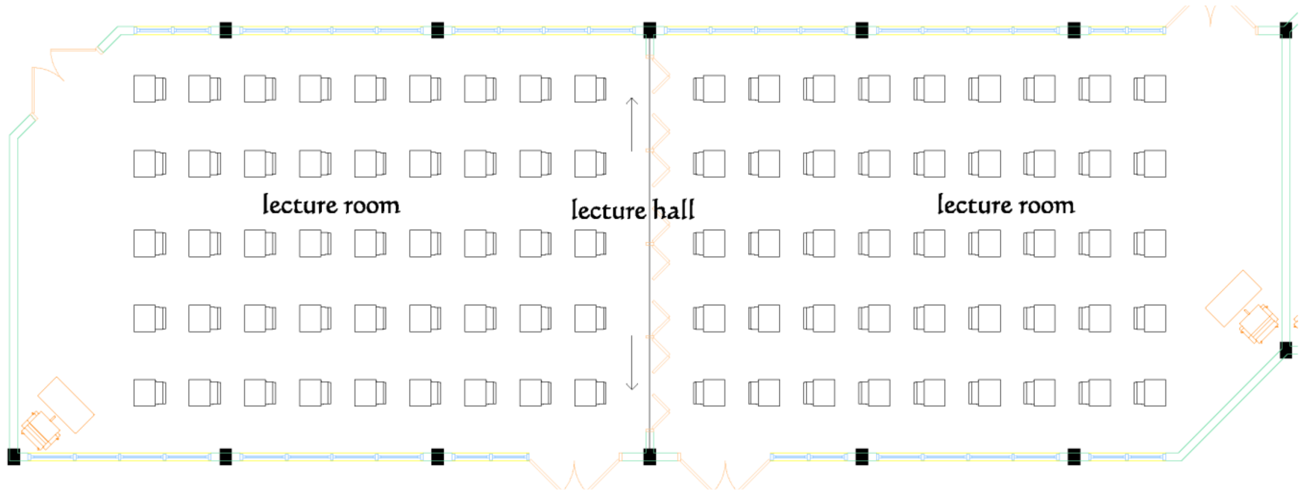


Figure 4.15: Foldable partition doors dividing lecture rooms

4.3.2 Drill Yard

The drill yard has a total floor area of 10,000 square metres and as such is able to accommodate various training activities simultaneously. The activities carried out here include physical training. Firefighting drills involving liquefied petroleum gas (LPG) take place on the drill yard. The use of this open space (the drill yard) for fire drills involving LPG reduces the risks of accidents as compared to the use of an enclosed structure. It also makes maximum use of the site and specifically, the drill yard, as there is no need for the provision of a separate area or field for these drills. The drill yard also serves as parade grounds for passing-out ceremonies for recruits. To the northern end of the drill yard are the burn building and the drill/hose tower. A podium is provided at the southern end of the drill yard as shown in Figure 4.16 to seat dignitaries during passing- out ceremonies.

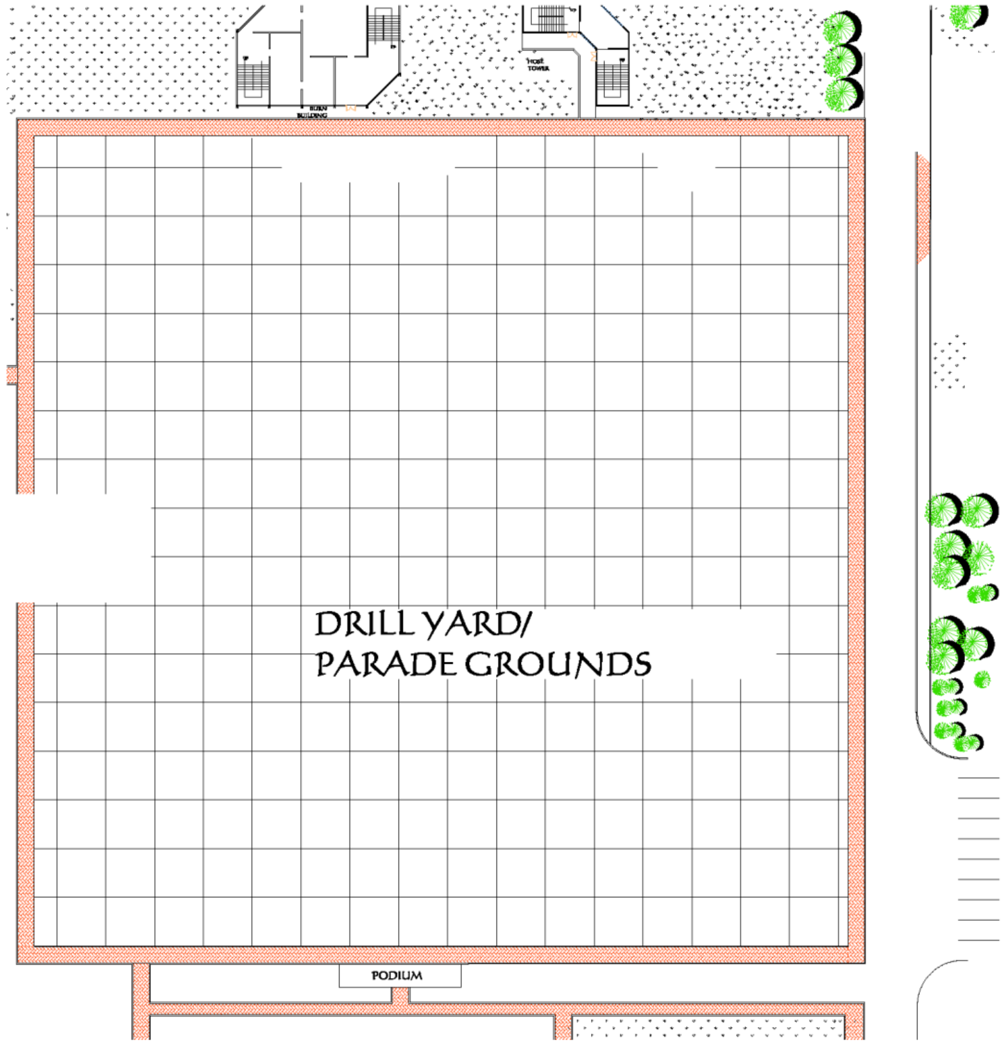


Figure 4.16: Ground floor plan of the drill yard

4.3.3 Administration and Support Facilities

The administration block is a two storey structure which mainly houses the teaching staff offices for the administrative duties of the school. It also houses meeting rooms, staff lounges and storage areas. As shown in Figure 4.17, provision is made for the physically handicapped to access the building on the ground floor by means of a ramp at the entrance of the building.

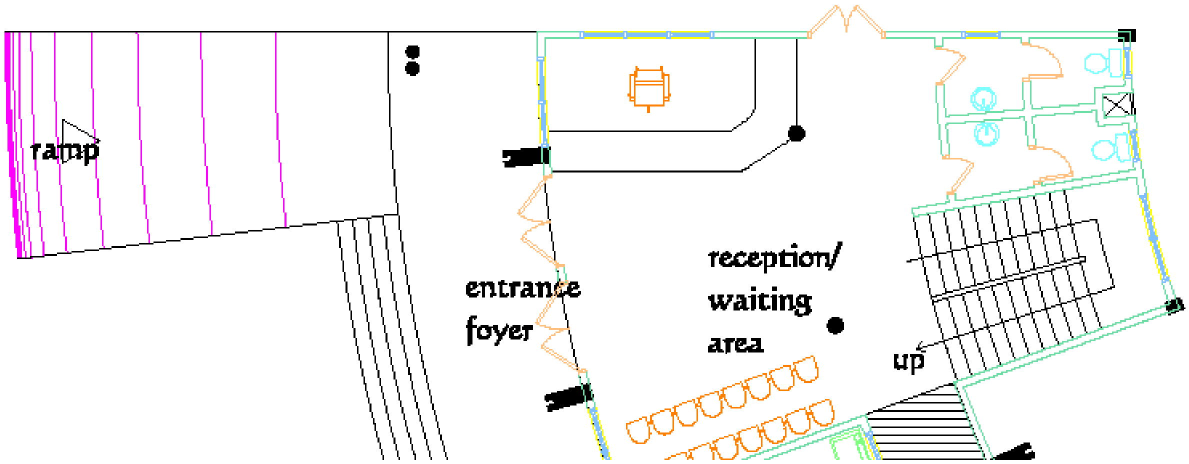


Figure 4.17: Ramp for the physically handicapped

4.3.4 Fire Station

A fire station is designed with the provision of a spacious crew room, separate changing rooms and sanitary facilities for males and females (Mion, 2008). Apart from the stairway, the use of the fireman’s pole as shown in Figure 4.18 is employed as an alternative and faster means of vertical circulation from the crew room (on the first floor) to the apparatus/appliance bay (on the ground floor).

Figure 4.18: The fireman’s pole for vertical circulation

4.3.5 Multi-purpose Hall

With a total capacity of 450 seats, the multi-purpose hall is designed to accommodate activities such as ceremonies, religious activities, seminars and sometimes indoor training sessions when the need arises (during windy, stormy or rainy conditions). The floor finish for the main hall of the multi-purpose hall is terrazzo to withstand the indoor training sessions. The hall is fitted with moveable seats as stated by Elmore (2001) to allow flexibility in arrangement for any one of the intended uses. Access to the entrance foyer of the multi- purpose hall is by means of a ramp.

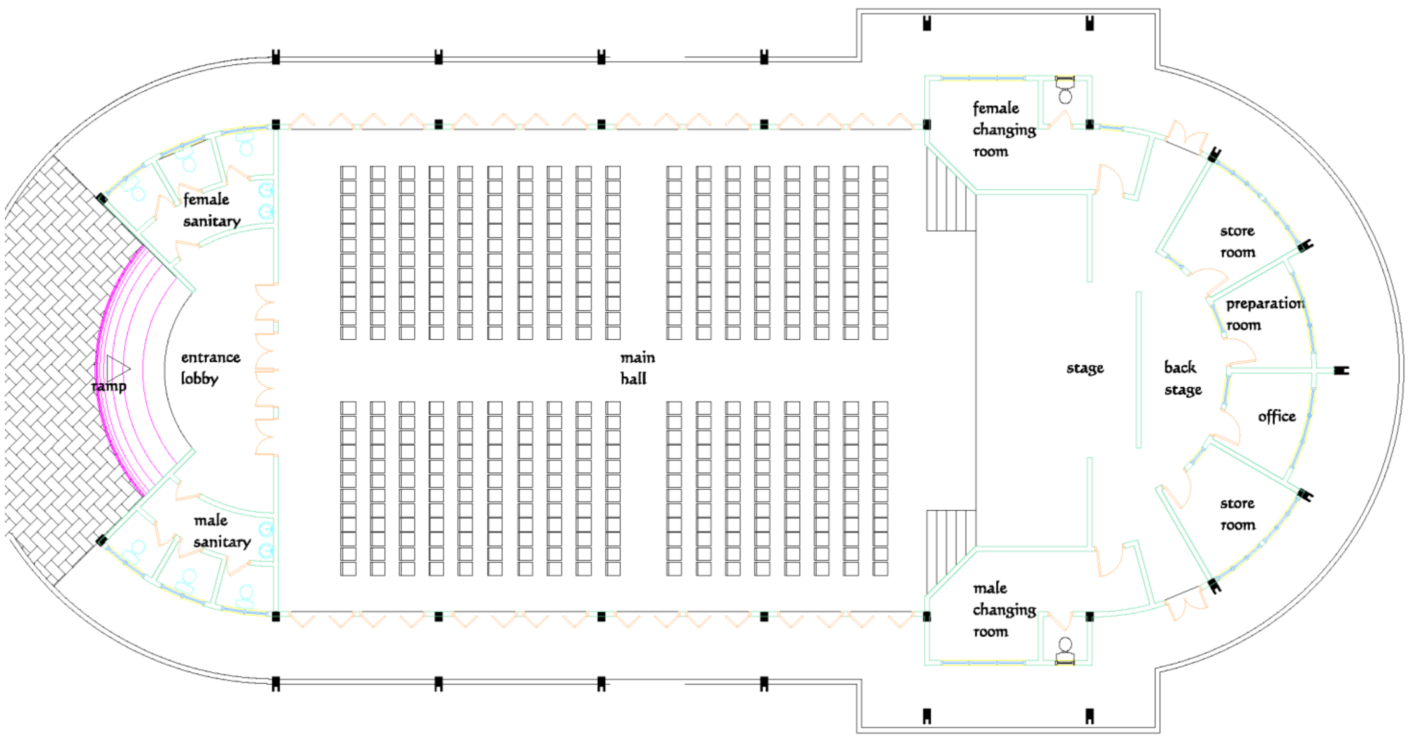


Figure 4.19: Ground floor plan of the multi- purpose hall.

4.4 SPECIALIZED COMPONENTS OF THE PROPOSED MODEL FIREFIGHTING TRAINING SCHOOL FOR GHANA

The provision of a burn building, a training or drill tower and a smoke building in the model firefighting training school constitute the main facilities referred to as specialized buildings.

4.4.1 The Burn Building

According to NFPA (2001), a combination building which incorporates compatible functions may be constructed. The burn building in this model training centre is one of such multi-purpose drill facilities as it combines the functions of the live fire structure and the smoke building. These two training activities are combined because they are both related to live-fire simulations.

The burn building which is four storeys high is strategically located on the leeward side of the site to reduce the amount of air pollution to other facilities in the school during training sessions. As stated by Elmore (2001) and Cote (2003), the construction of the burn building should be done with fire resistant materials such as concrete to withstand the extreme temperatures it is subjected to. The structural components of the burn building which would be subjected to a variety of live fire drills therefore consists of a framework of reinforced concrete slabs over concrete beams which are constructed independently from the in-fill which is made up of non load-bearing refractory blocks. This separation of the concrete shell from the walls provides ideal protection to the structural components since it allows the materials to expand and contract independently and consequently withstand the intensity of the temperatures it is exposed to. This to a large extent will increase the life expectancy of the burn building. Vertical circulation within the burn building is by means of a staircase and this can be used to simulate different fire scenarios as in the case of multi-storey buildings. Compartmentation (division of the building into smaller partitions) as illustrated in Figure 4.20 is employed to contain the spread of fire thus reducing the risk of accidental fire outbreaks in the burn building. The internal partitions are made up of fire walls with a one-hour fire rating, to contain fire used for training sessions, reducing the risk of such fires from spreading to adjoining spaces. All the doors provided in the burn building are one-hour fire rated doors. Fire rated windows which open outwards are also provided in the burn building.

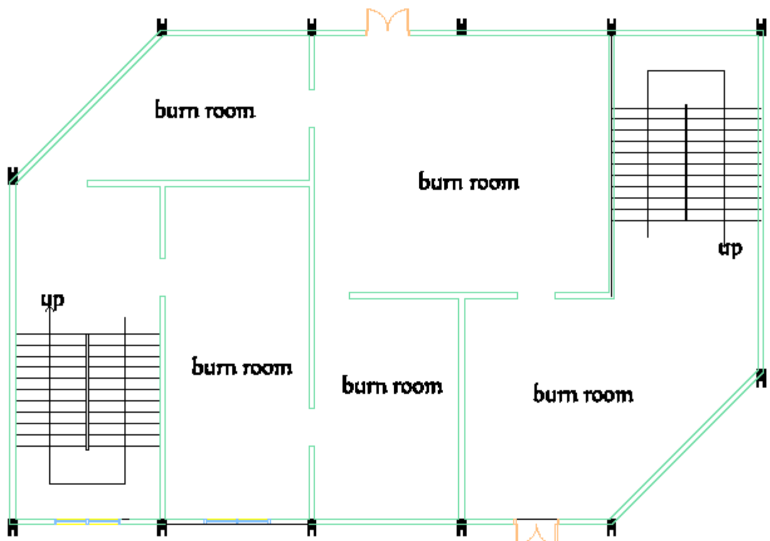


Figure 4.20: Ground floor plan of the burn building with the various compartments

4.4.2 The Hose/Drill Tower

The hose/drill tower is five storeys high with its wall and roof surfaces being flat to ensure safety when being laddered, rappelled or walked on. The building has balconies which act as shading devices and at the same time provide scenarios for training as in the case of buildings with balconies such as apartment blocks or office buildings. The void in the middle of the building is used for the drying of the hose as performed by the Fire Academy and Training School in Accra. Similar to the burn building, the hose tower is constructed with mass concrete to withstand the harsh temperatures and conditions it is subjected to. Rainwater is drained from the roof through P.V.C pipes which are provided within fins attached to the columns. Aprons are provided around the burn building and the hose tower to drain any excess water after training sessions to prevent any accidents that may occur.

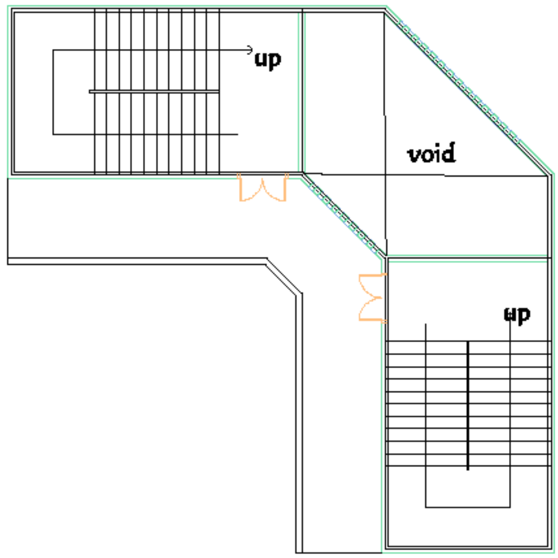


Figure 4.21: Ground floor plan of the drill/ hose tower

4.5 MATERIALS FOR THE CONSTRUCTION OF THE PROPOSED MODEL FIREFIGHTING TRAINING CENTRE FOR GHANA

Apart from the burn building and the hose tower which are constructed with concrete, all the other buildings in the training school are constructed with sandcrete blocks. Due to the fire related functions of the burn building, fire resistant steel is used in its construction to withstand the extreme temperatures it is subjected to. The entire boundary of all the roofs are protected with a one metre high parapet wall made of reinforced concrete, except for the structural live fire buildings where mass concrete is used.

In a facility such as a firefighting training school, finishes, especially, floor finishes for areas used for the practical aspect of the training are critical due to the kind of activity and force these areas are subjected to. The drill yard (which also doubles as the parade grounds) is the main area of activity. It is finished with concrete slabs to resist the wear and tear resulting from the vigorous activities it is subjected to. The areas that are used constantly such as the foyer, and lobbies as well as the classrooms are treated with terrazzo. The walkways are also paved with concrete pavement blocks whereas asphalt is used for the roads.

4.6 CIRCULATION PATTERNS

Circulation between the various facilities in the training school is efficiently designed by the use of interconnected walkways and roads throughout the entire facility as shown in Figure 4.22. There is easy accessibility to and from the drill yard, the central core, and all other facilities. This ensures its effective and efficient use by both firefighters from the fire station and recruits as well.

4.7 FIRE SAFETY AT THE PROPOSED MODEL FIREFIGHTING TRAINING CENTRE FOR GHANA

The issue of fire safety cannot be overlooked in such a facility. Apart from the provision of fire escape stairs/exits at appropriate points in the various components of the training facility, fire extinguishers and smoke detectors as well as fire alarm systems are provided to automatically detect and control fire. Fire rated doors and fire windows (with 20-30 minute fire resistance) as well as fire walls (with one-hour fie resistance) are provided at appropriate locations in the school to reduce the spread of fire to other facilities on the site. Compartmentation is also employed in the burn building to control the spread of fire from one space to another. This will help contain the fire until attempts are made by trainees to extinguish it. Fire hydrants are also strategically located to aid in fighting fire during training sessions.

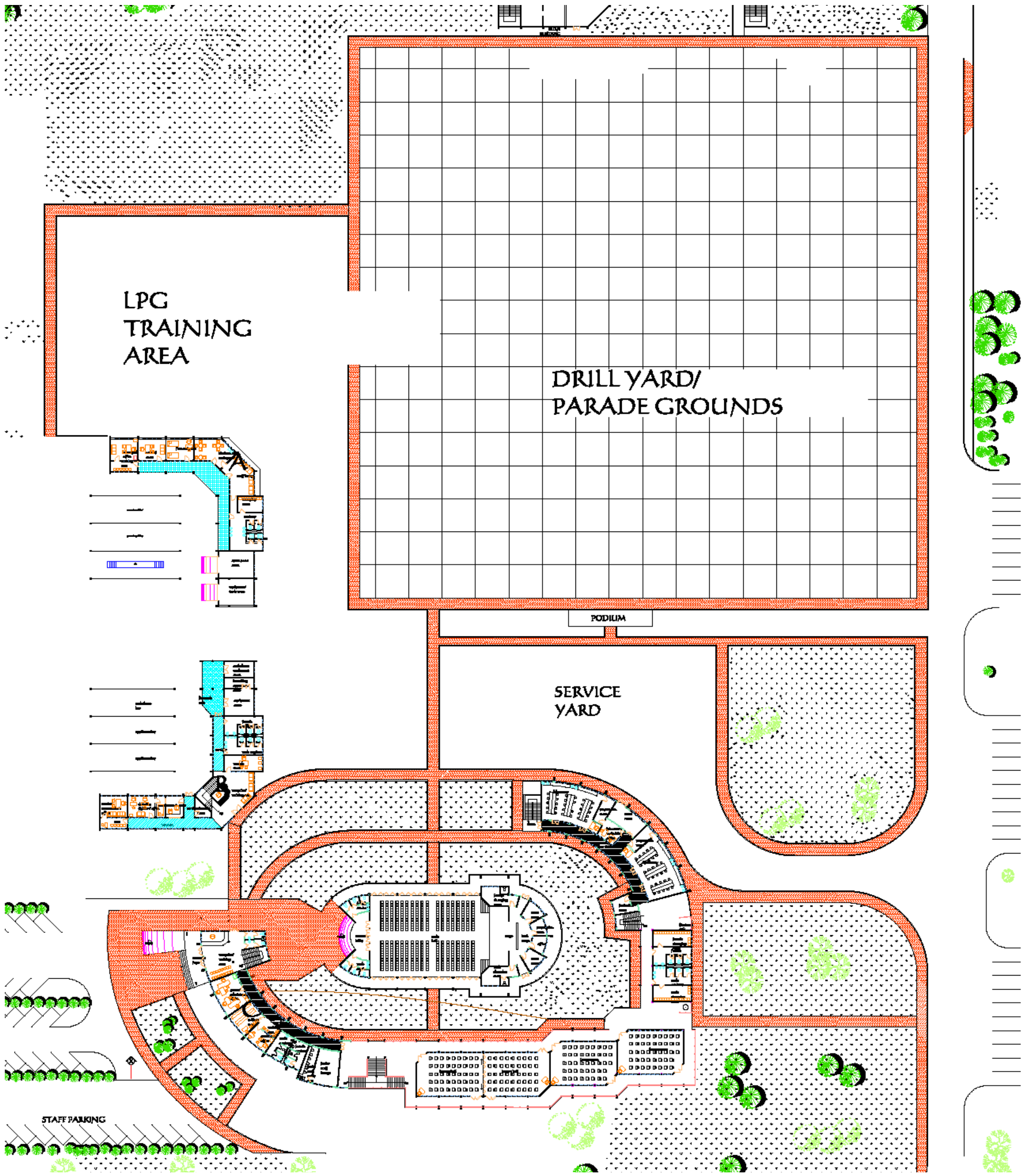


Figure 4.22: Circulation pattern showing interconnected walkways

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

A total number of 2,819 fire outbreaks were recorded in the year, 2007 resulting in various degrees of casualties including the loss of human lives and property. The presence of only one training school in Ghana, the Fire Academy and Training School limits the number of recruits admitted per training period. This makes the ratio of firefighters per population in Ghana, 1:3667 woefully inadequate as compared to the ideal ratio of 1:800. The unavailability of some relevant and mandatory facilities required in firefighting training schools limits recruits in the acquisition of skills during training sessions since they have to devise ways of achieving results which would otherwise be easily achieved if the appropriate facilities were available. This to a large extent affects the quality of training and consequently the performance of firefighters at the scenes of fire outbreaks as they are not exposed to a variety of live-fire scenarios and as such cannot do much to put such fires under control when the need arises.

5.2 RECOMMENDATIONS

The issue of firefighting and its training should not be compromised in any way. Every effort should be made to provide a favourable and enabling environment for the training of firefighters in the country. The Ministry of Interior and other stakeholders should put in place the necessary measures in terms of logistics and appropriate training facilities for personnel of the Ghana National Fire Service. It is recommended that a new state-of–the–art firefighting training centre with a variety of facilities to provide training in a wide range of firefighting scenarios be set up. It is therefore recommended that the proposed model design be adopted for training in a wide range of fire scenarios to ensure the versatility of firefighters whose aims are to save lives, property and offer humanitarian services. It is also recommended that regional training centres be provided and more fire stations be constructed, at least one in every district of Ghana. Motivational packages for firefighting personnel would also serve as incentives to enhance their response to distress calls.

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Appendix A:

Sample Questionnaire Form and Response to Questionnaire

Sample Questionnaire Form

1. How many firefighting training schools/centres are there in Ghana?

   ………………………………………………………………………………………………

2. How many students/recruits are admitted per training period?

   ………………………………………………………………………………………………

3. How long is the training period for firefighters?

   a. Recruits ………………………….

   b. Officer cadets ……………………

4. What types of training or drills are undertaken to fully equip firefighters?

   ………………………………………………………………………………………………

5. What types of buildings/facilities are available for the training of firefighters in Ghana?

   ………………………………………………………………………………………………

6. Are the available facilities appropriate for training?

   Yes …………….

   No……………. If no, why?..

7. Are the available facilities adequate for the training of firefighters in Ghana?

   Yes …………….

No……………. If no, why?..

8. Are you satisfied with the facilities available for the training of firefighters in Ghana?

   Yes …………….

   No……………. If no, why?..

9. Do you feel there is the need for the establishment of other firefighting training centres in Ghana?

   Yes …………...If yes, why?

   No……………. If no, why?..

10. How would you rate the Ghana National Fire Service in terms of the following:

    i. Logistics Excellent……………….

    Average………………..

    Poor…………………....

    ii. Infrastructure Excellent……………….

    Average………………...

    Poor…………………….

    iii. Conditions of service Excellent……………….

    Average………………..

    Poor……………………

Response to Questionnaire

Questionnaires were administered to thirty (30) firefighters; twenty-three (23) officers at the headquarters of the Ghana National Fire Service in Accra and seven (7) instructors at the Fire Academy and Training School (FATS) in James Town, Accra. Out of these, twenty-two (22) firemen responded with results as follows:

1. How many firefighting training schools/centres are there in Ghana?

   One (1)

2. How many students/recruits are admitted per training period?

   250 - 300

3. How long is the training period for firefighters?

   a. Recruits -6 months

   b. Officer cadets -9 months

4. What types of training or drills are undertaken to fully equip firefighters?

   Rescue exercises, ladder drills, pump drills, hydrant drills, tunnel drills and road accident drills

5. What types of buildings/facilities are available for the training of firefighters in Ghana?

   Hose tower

   Smoke chamber

Fire station

6. Are the available facilities appropriate for training?

   Yes…….. 2

   No……. 20. If no, why?...

7. Are the available facilities adequate for the training of firefighters in Ghana?

   Yes …….. 0

   No………. 22. If no, why?..

8. Are you satisfied with the facilities available for the training of firefighters in Ghana?

   Yes ……… 1

   No………. 21. If no, why?...

9. Do you feel there is the need for the establishment of other firefighting training centres in Ghana?

   Yes……….. 22 If yes, why? To enable the training of more firefighters

   No……………. If no, why?..

10. How would you rate the Ghana National Fire Service in terms of the following:

    i. Logistics Excellent……… 0

       Average………. 4

       Poor………… .18

ii. Infrastructure Excellent……….0

Average……….....7

Poor…………….15

iii. Conditions of service Excellent…………..0

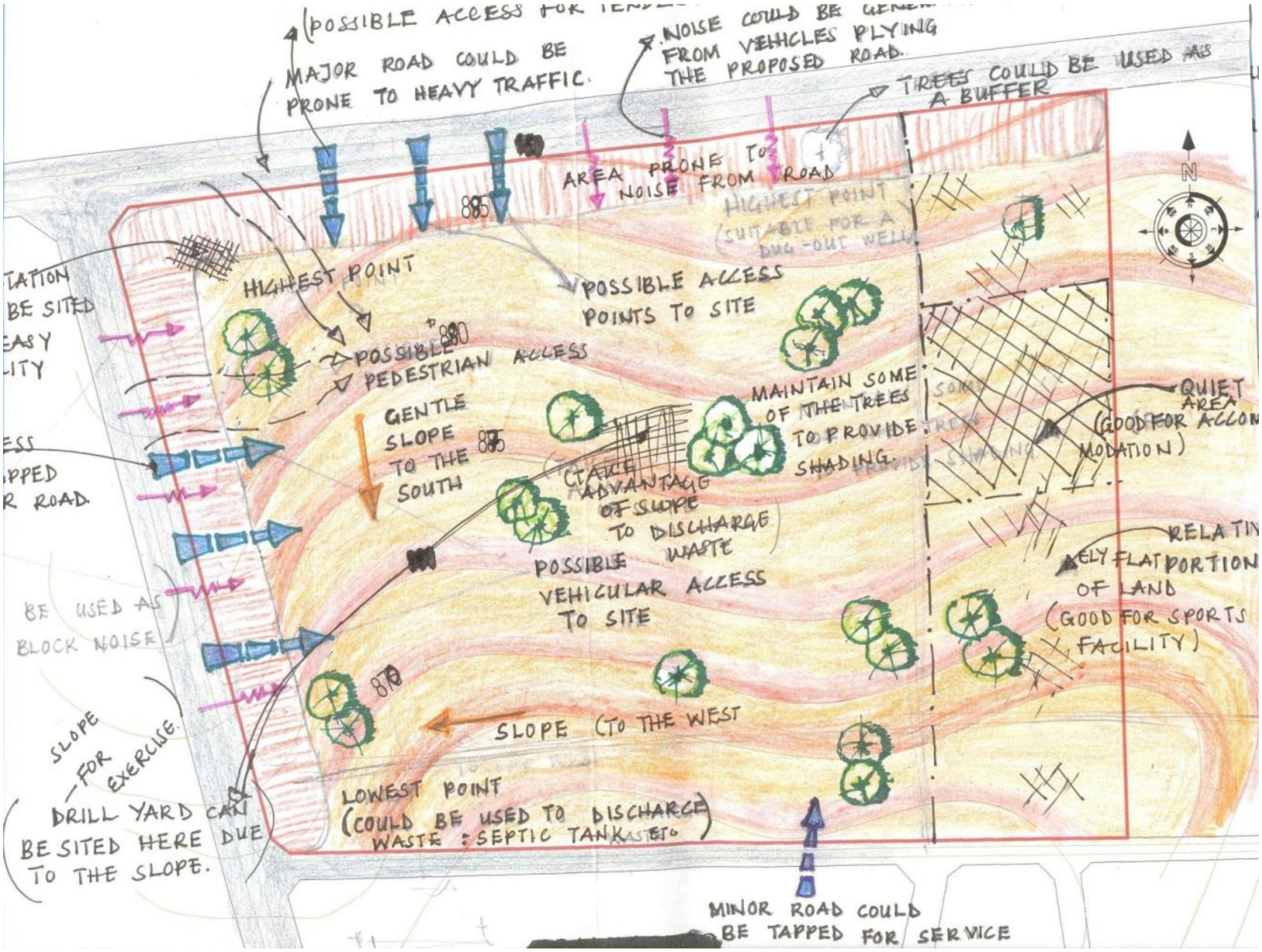
Average……………1

Poor………………21

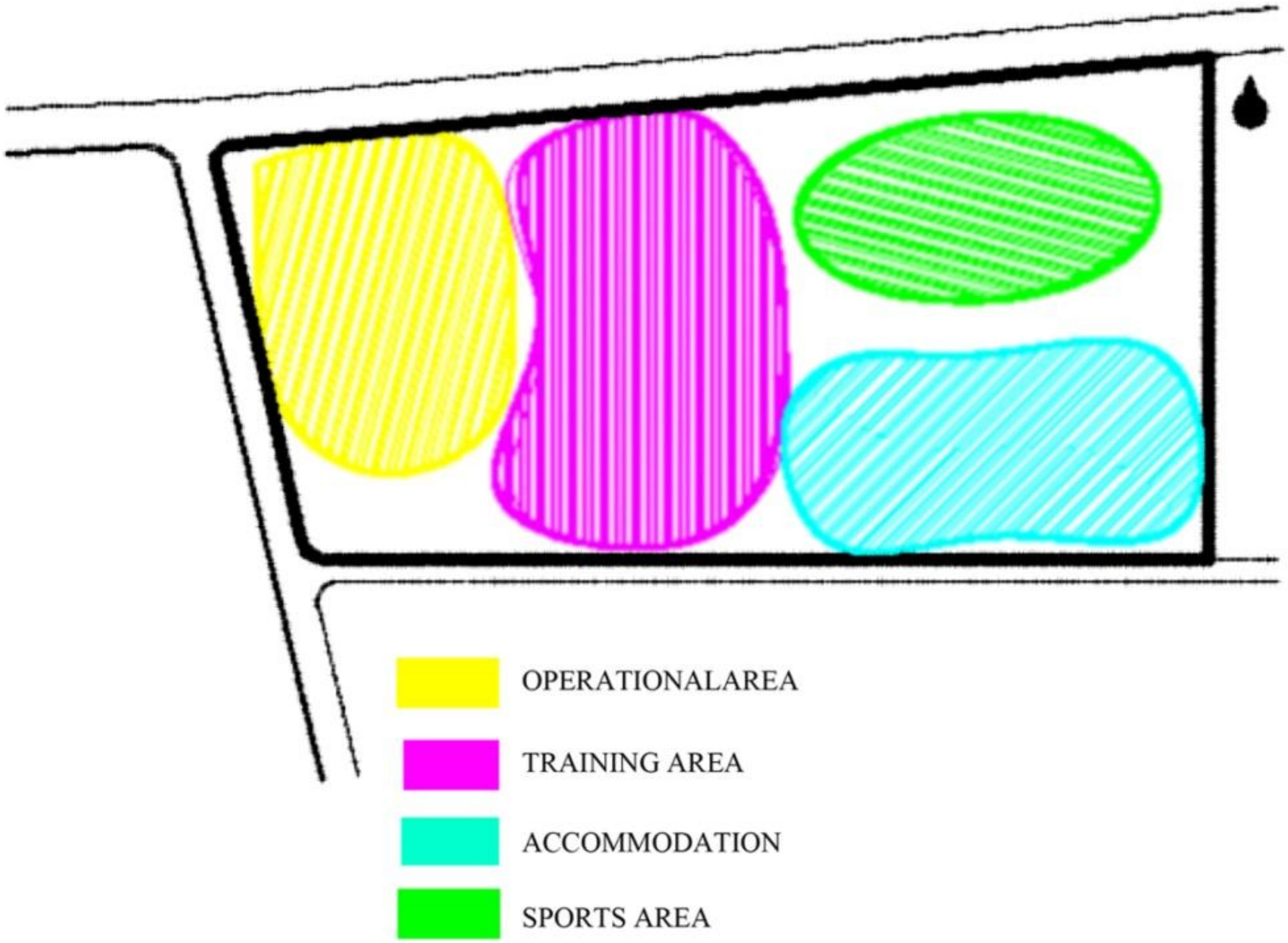
Appendix B:

Site Analysis, Zoning of Site and Conceptual Site Planning

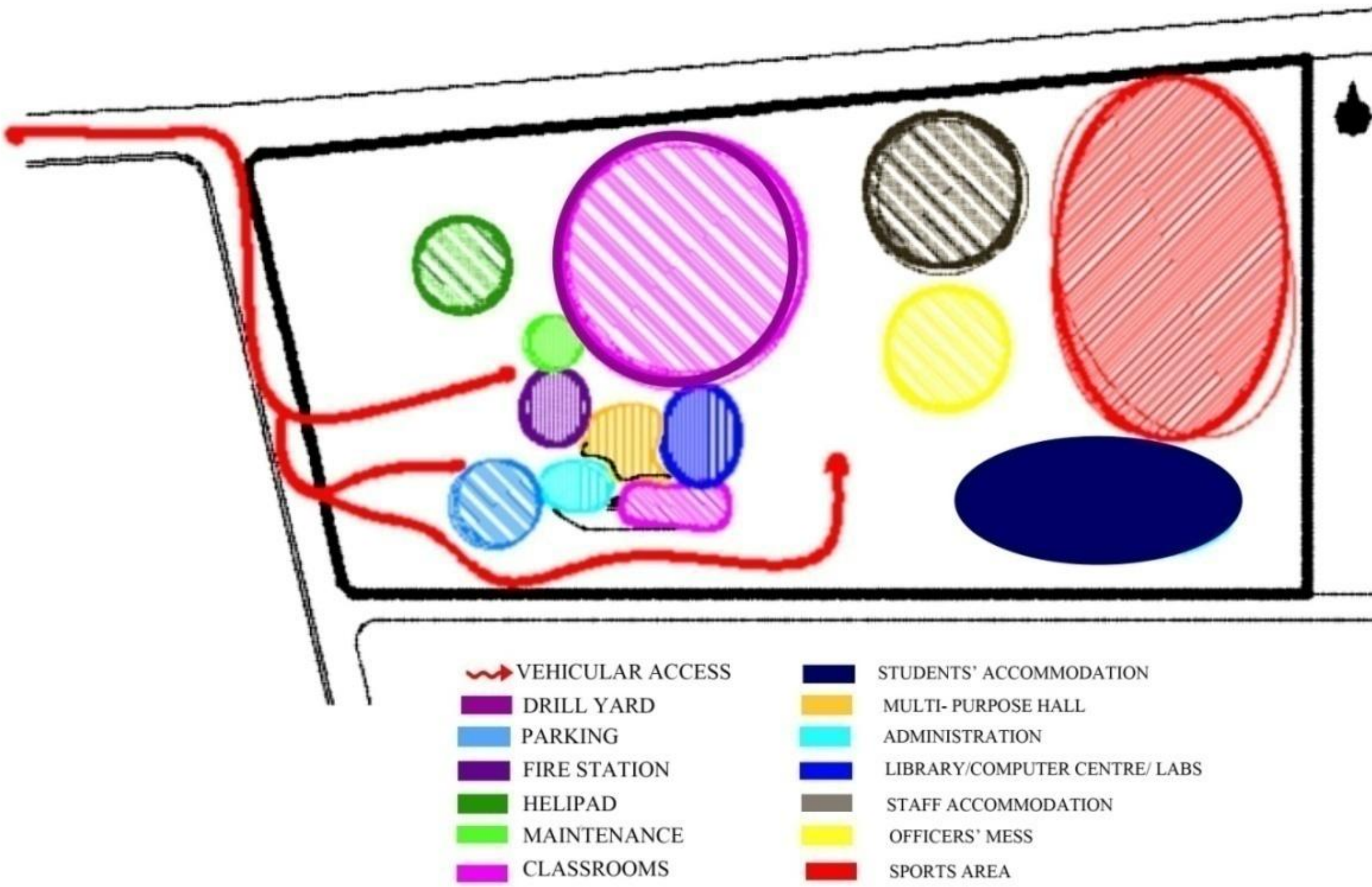
Site Analysis



Zoning of Site



Conceptual Site Planning



Appendix C:

Architectural Drawings of the Model Firefighting Training Centre

Appendix D:

Exterior Perspective Views of the Model Firefighting Training Centre

The main entrance to the facility

An aerial view of the fire fighting training centre

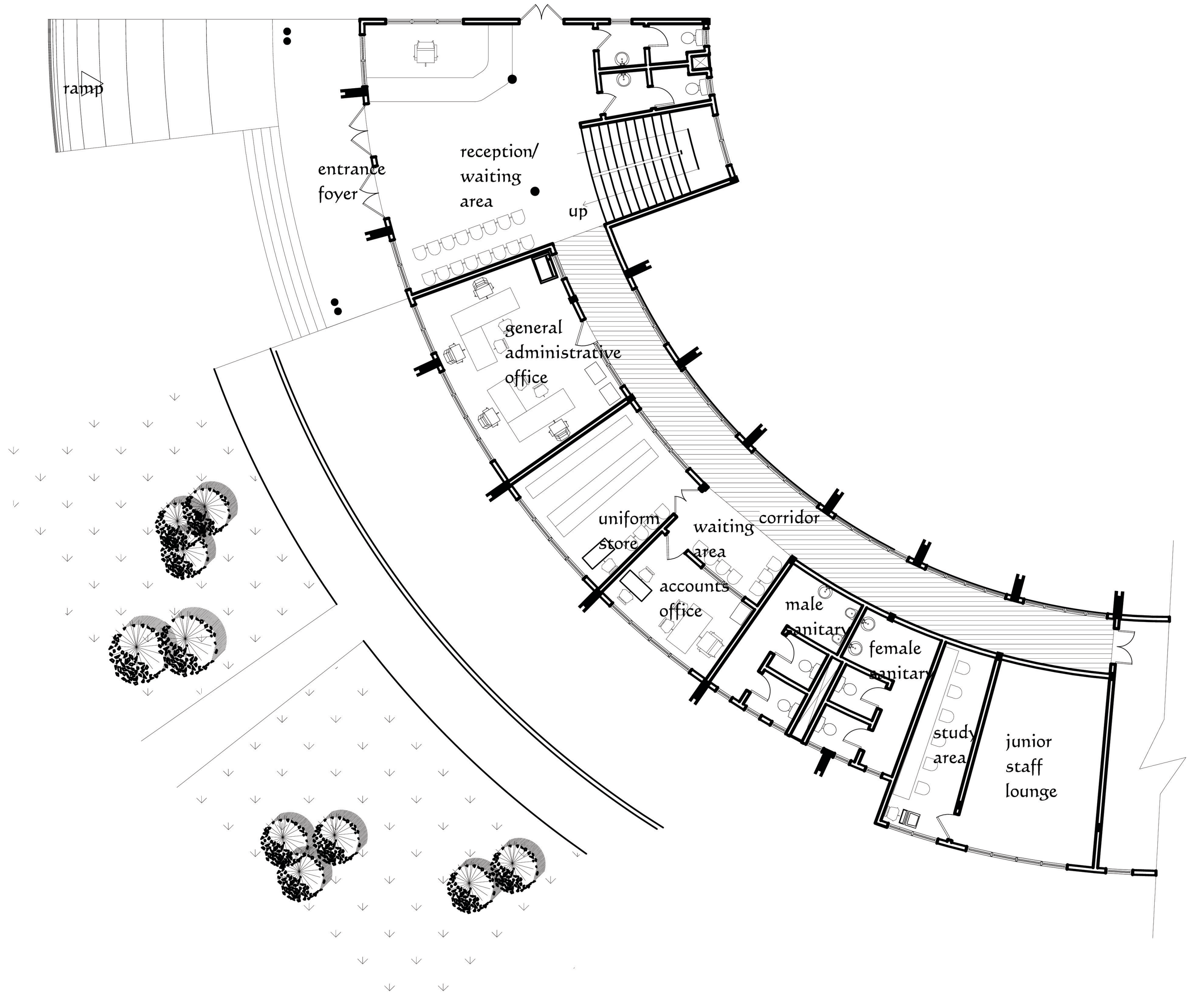
Front view showing the administration and the fire station

A view of the maintenance yard

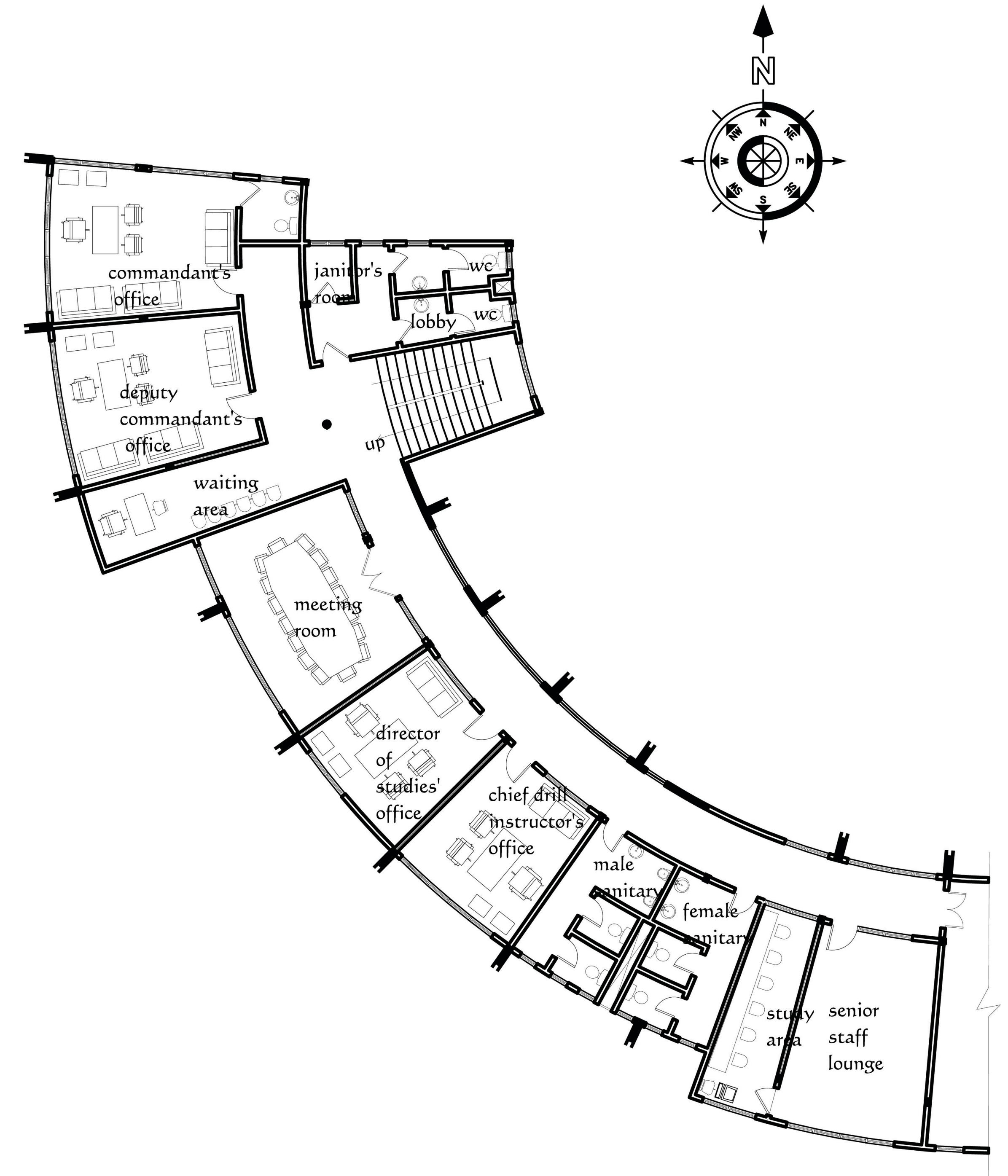
H
HELIPAD
G
DRILL YARD/
PARADE GROUNDS
PODIUM
SERVICE
YARD
A
B
D
O
E
F
J
K
L
M
N
FUTURE
DEVELOPMENT
N
LEGEND
A- Maintenance Unit
B- Fire Station
C- Administration Block
D- Classroom Block
E- Students' Accommodation
F- Dining Hall
G- Burn Building
H- Helipad
I- Hose Tower
J- Senior Staff Accommodation
K- Senior Officers' Mess
L- Gymnasium
M- Junior Officers' Mess
N- Junior Officers' Accommodation
O- Multi purpose Hall

BLOCK PLAN

ADMINISTRATION BLOCK

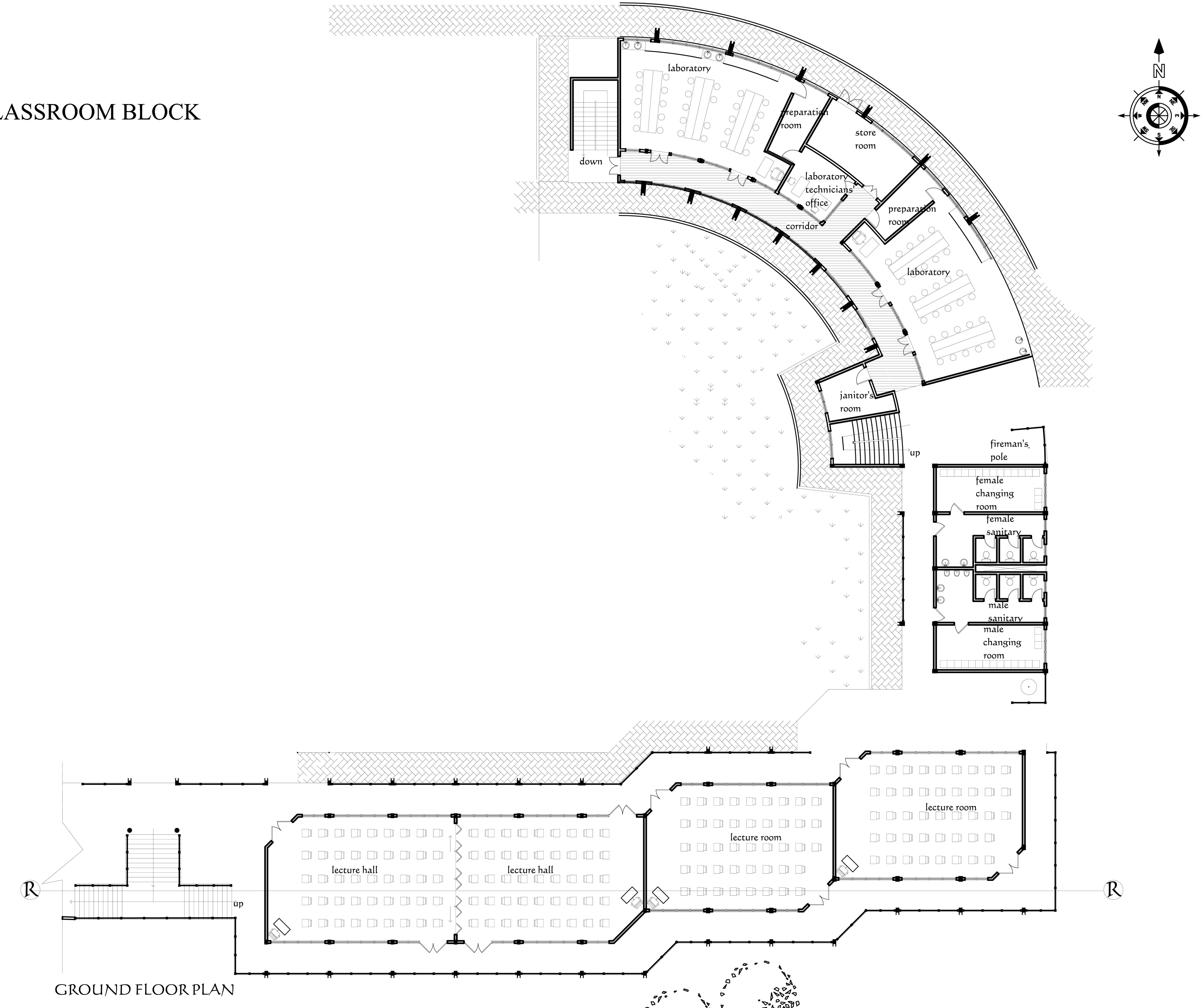


GROUND FLOOR PLAN



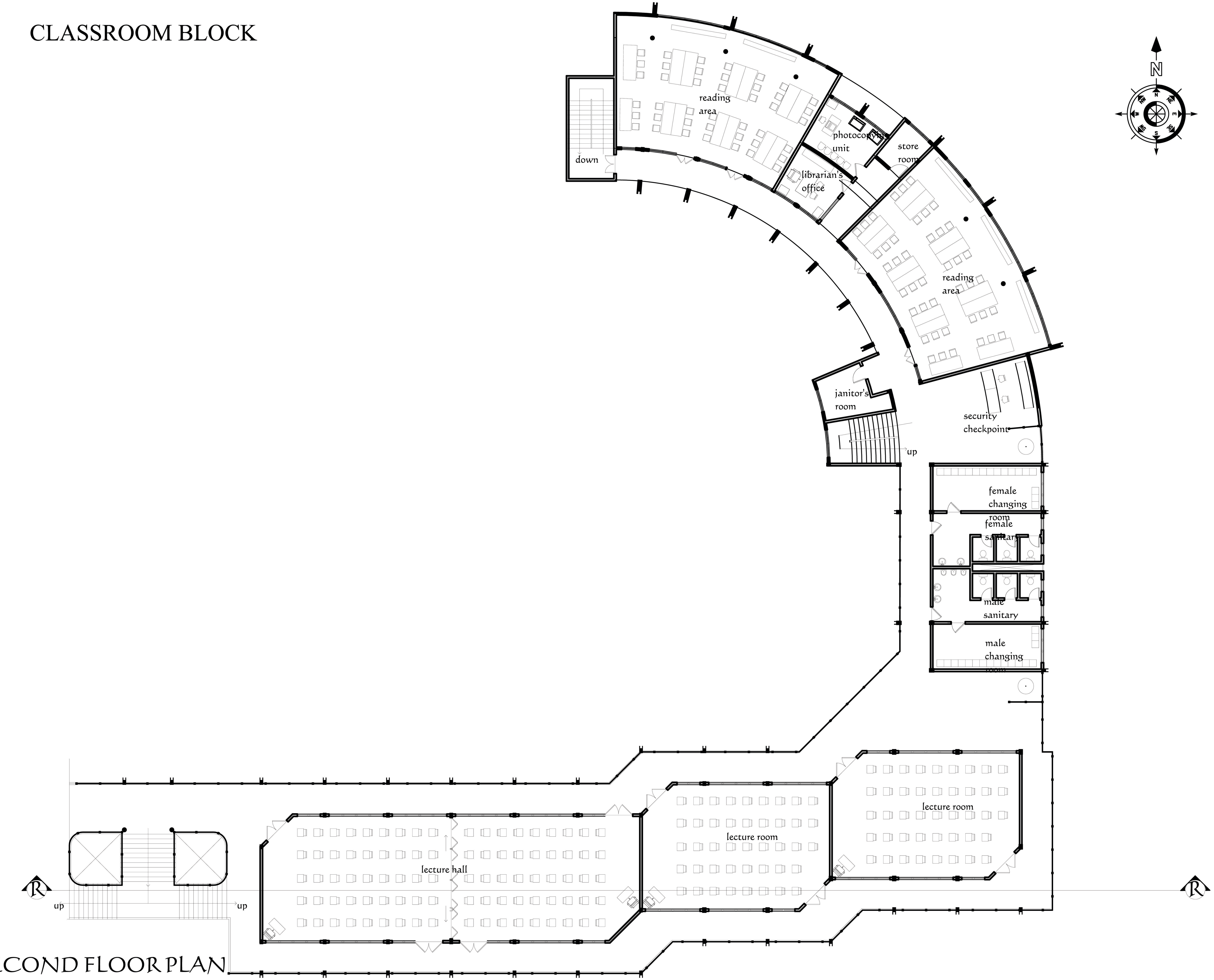
FIRST FLOOR PLAN

CLASSROOM BLOCK



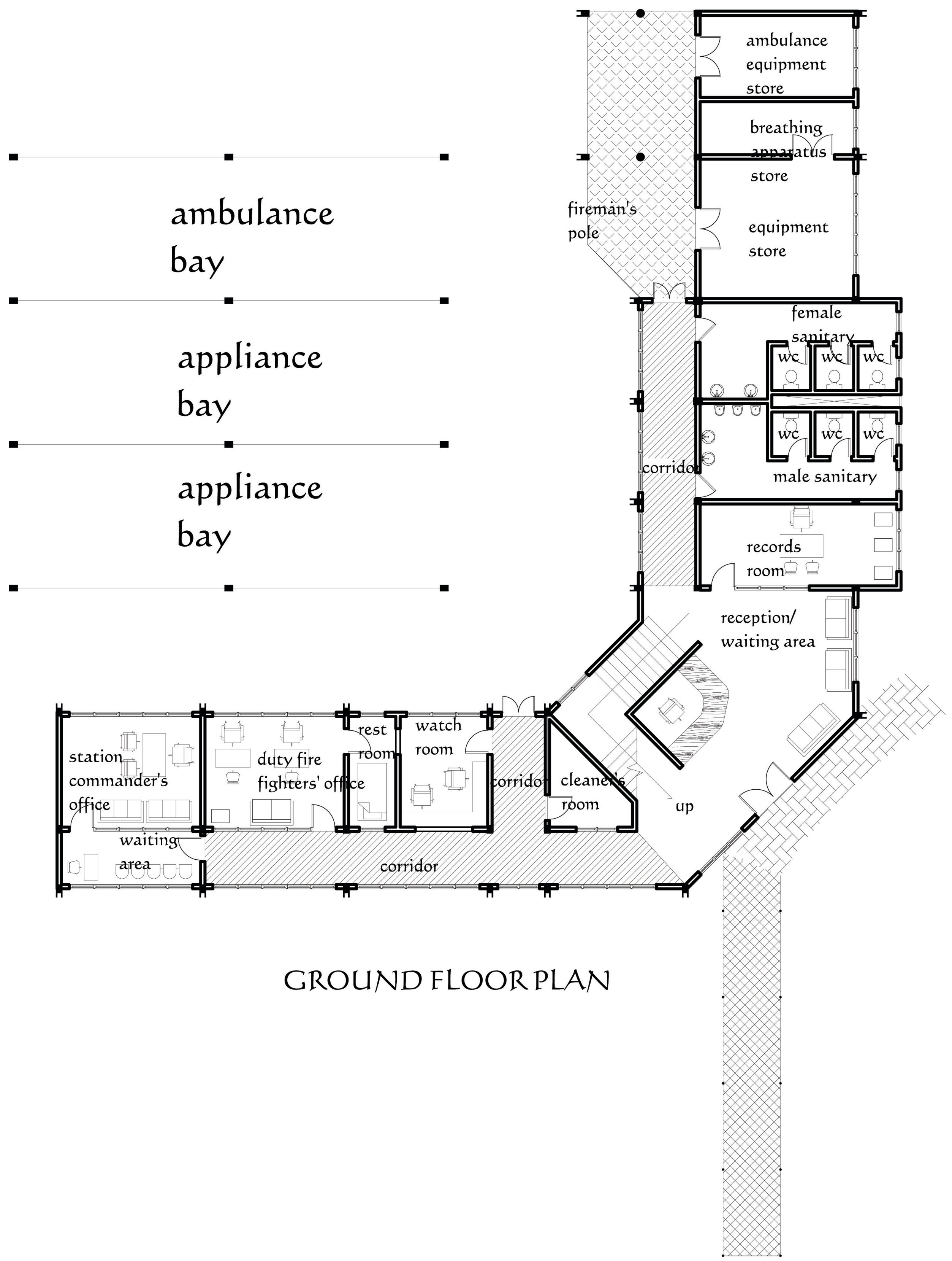
GROUND FLOOR PLAN

CLASSROOM BLOCK

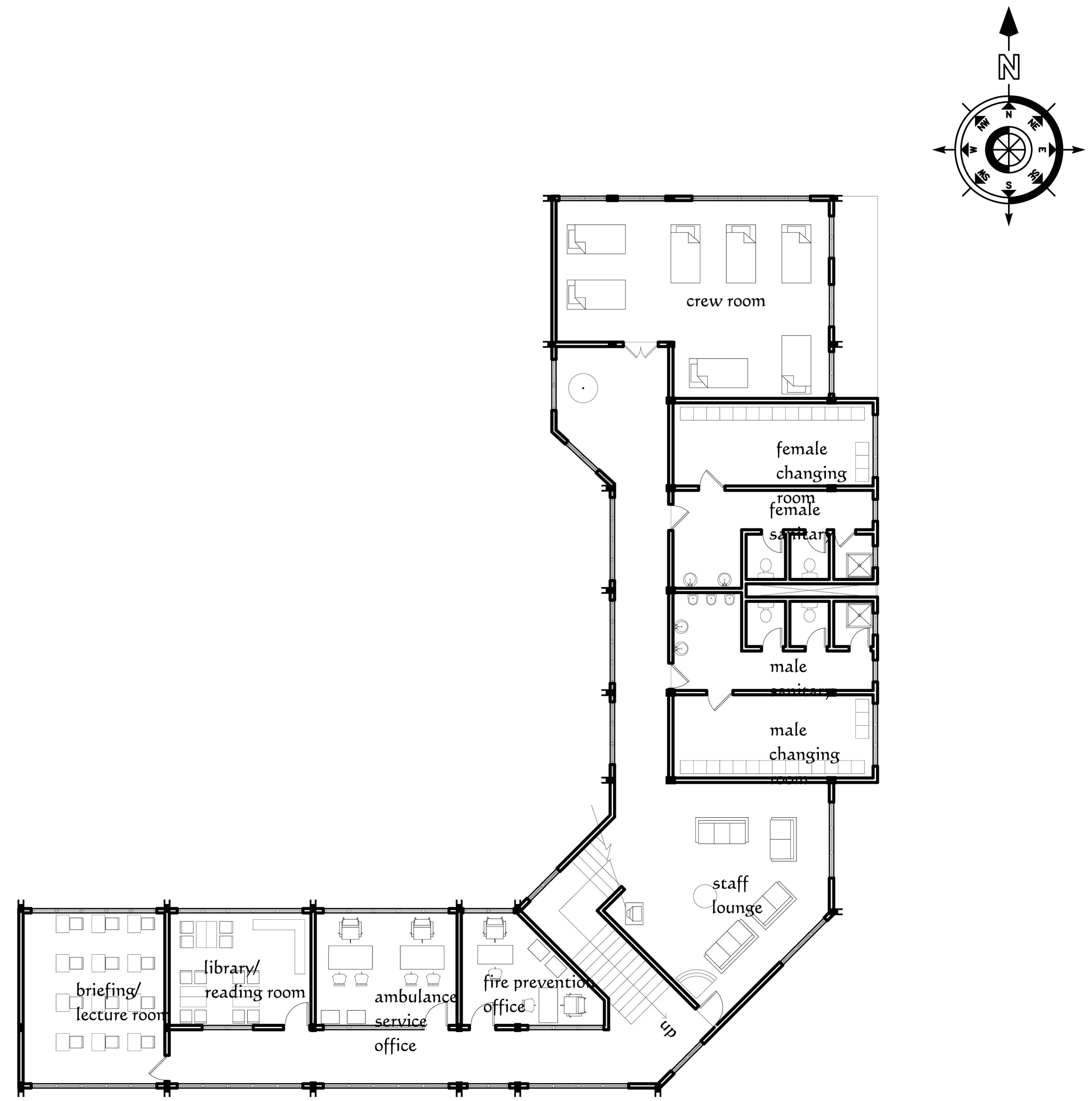


SECOND FLOOR PLAN

FIRE STATION

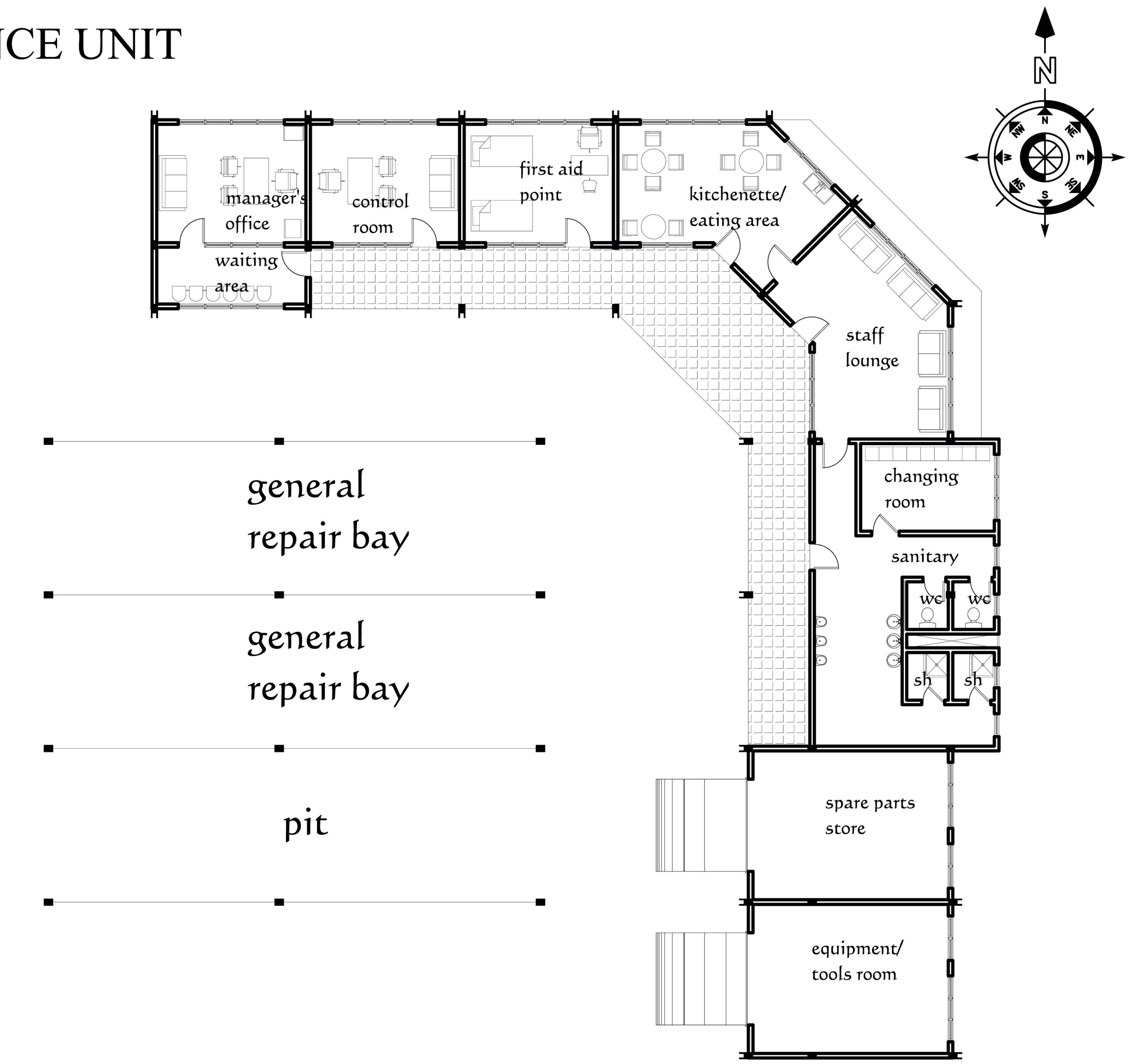


GROUND FLOOR PLAN



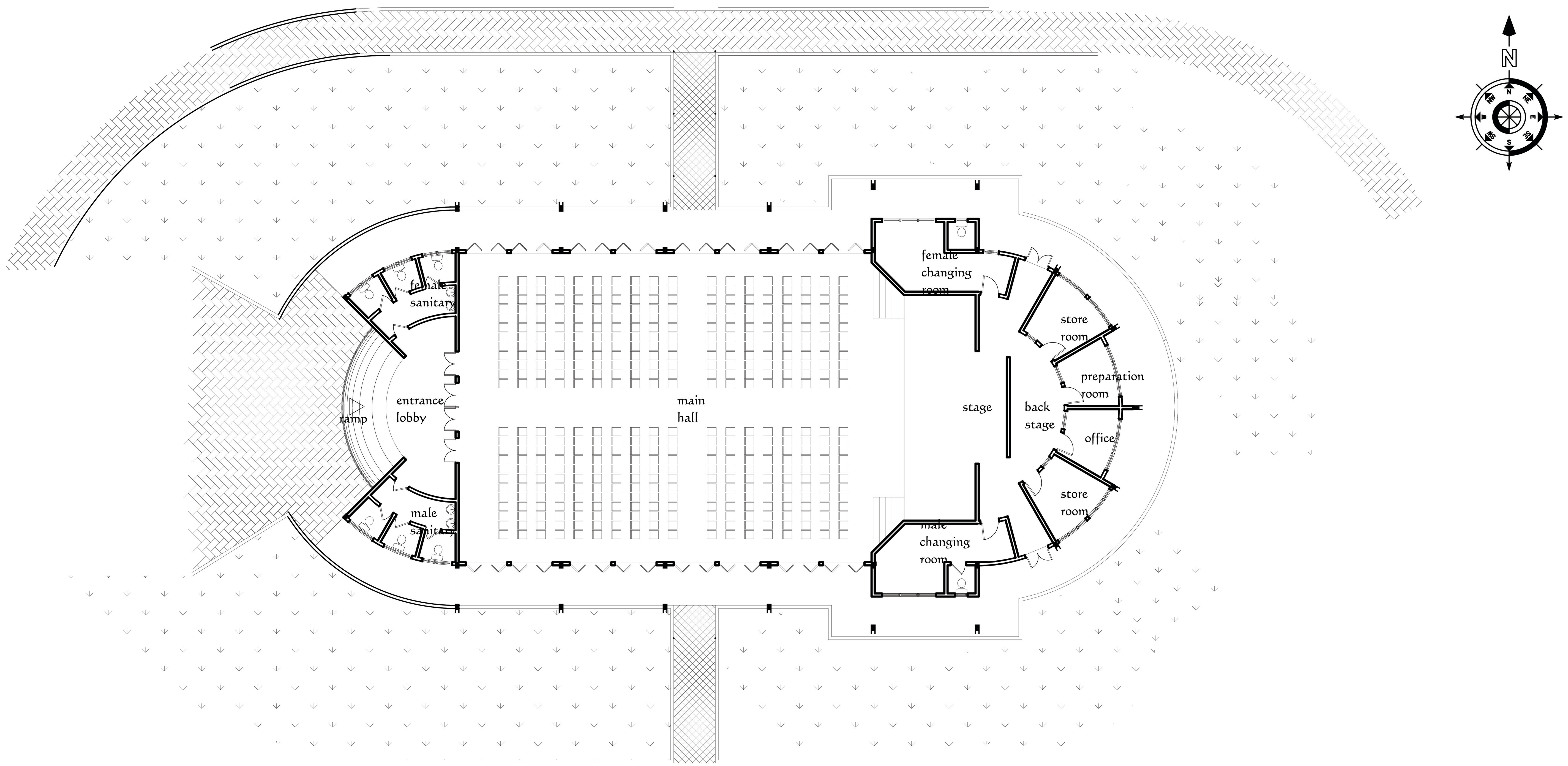
FIRST FLOOR PLAN

MAINTENANCE UNIT



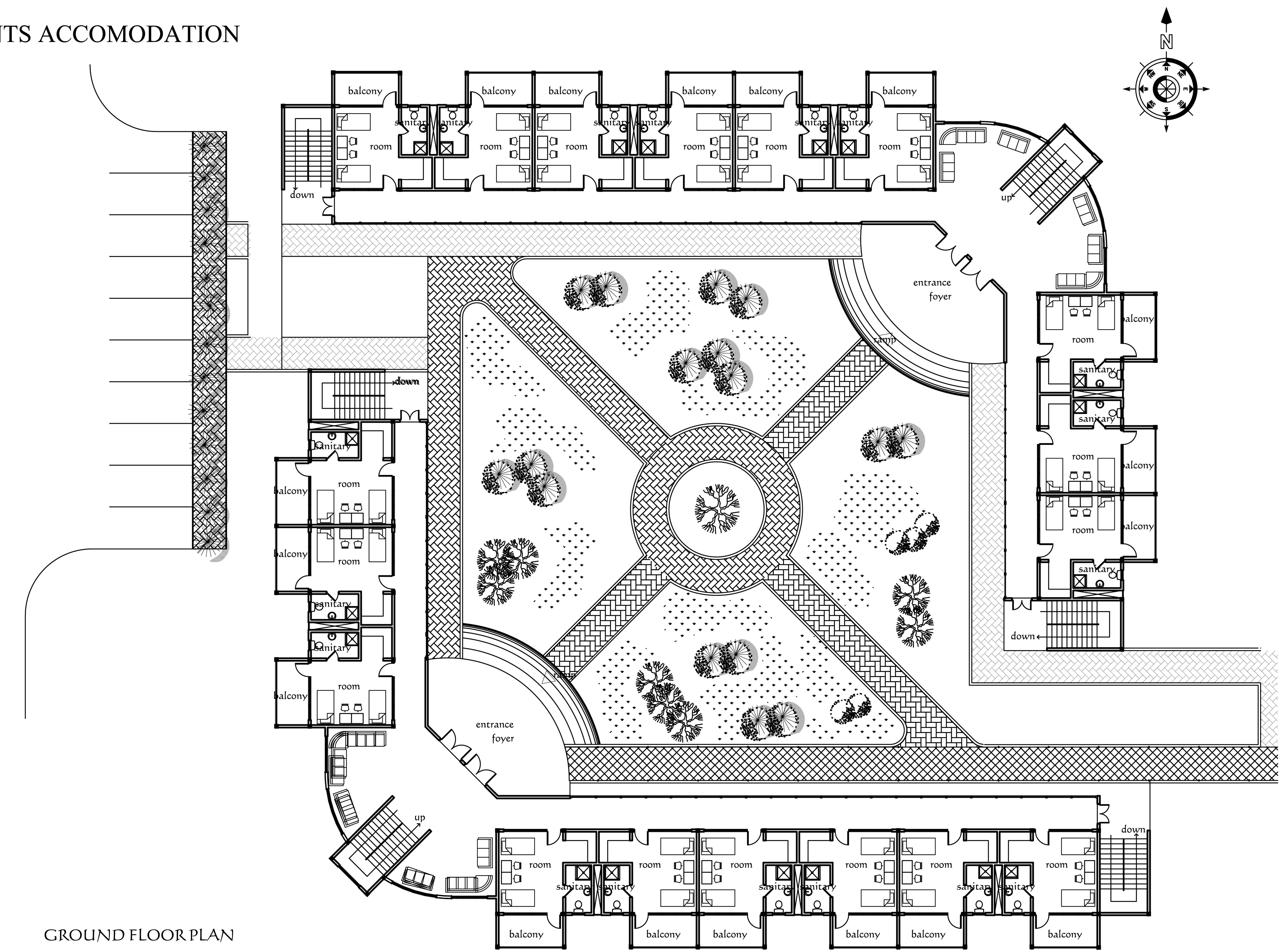
GROUND FLOOR PLAN

MULTI- PURPOSE HALL



GROUND FLOOR PLAN

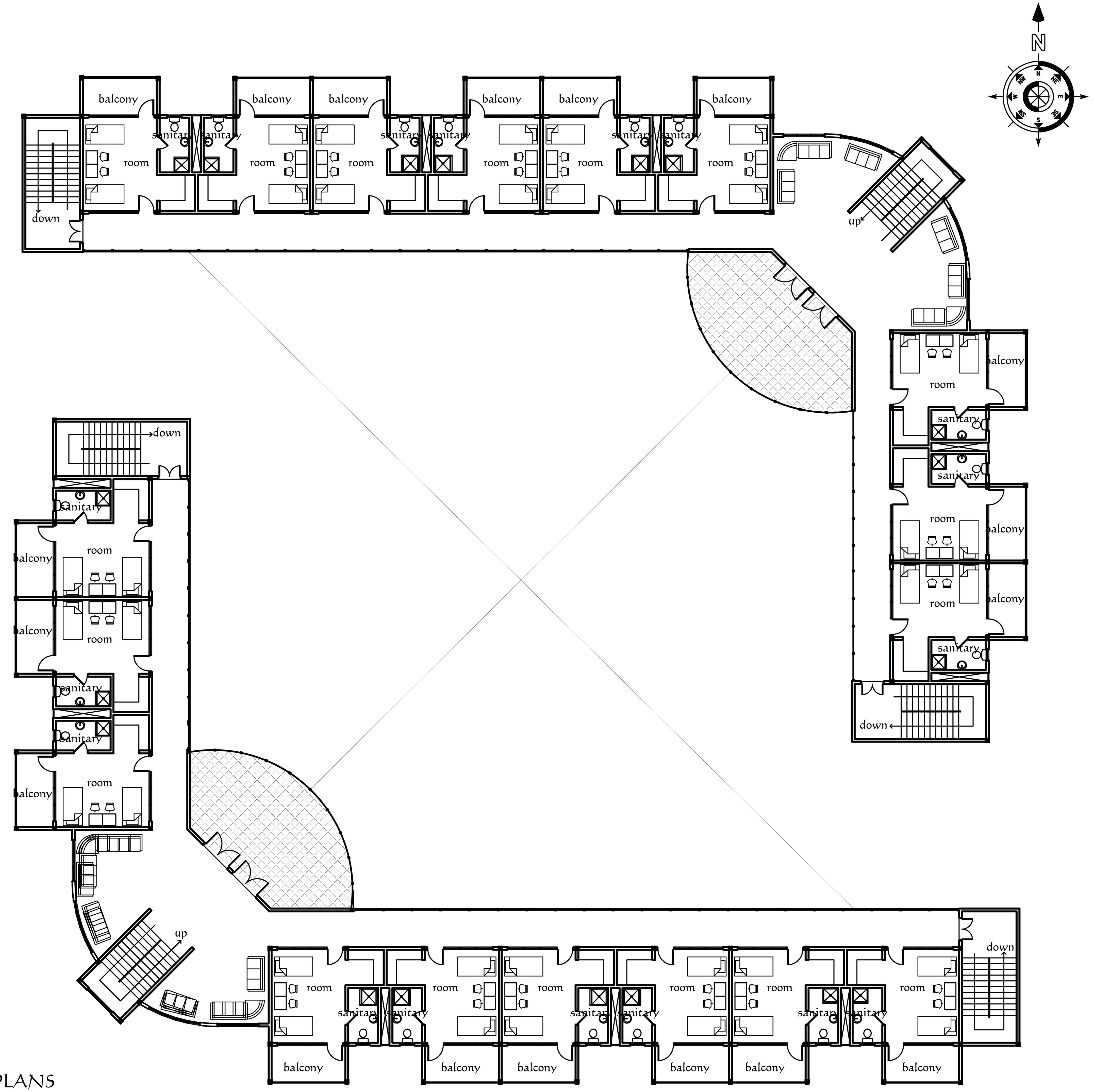
STUDENTS ACCOMODATION



GROUND FLOOR PLAN

plans

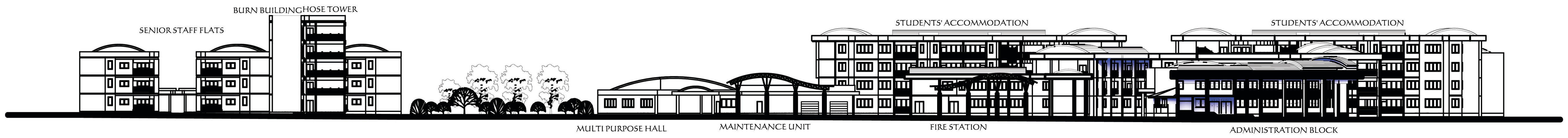
STUDENTS ACCOMODATION



FIRST- THIRD FLOOR PLANS

SOUTHERN ELEVATION

NORTHERN ELEVATION



WESTERN ELEVATION