MARINE MUSEUM, UNIVERSITY OF LAGOS, LAGOS.

(THE EFFECT OF WATER ON BUILDINGS)

M. TECH THESIS (ARCHITECTURE)

BY

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REG. NO. M.TECH/SET/701/2000/2001

A THESIS SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE, SCHOOL OF POST-GRADUATE STUDIES, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE. IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF TECHNOLOGY DEGREE IN ARCHITECTURE (M.ARCH)

DEPARTMENT OF ARCHITECTURE, SCHOOL OF POST-GRADUATE STUDIES.

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA, NIGER STATE.

FEBUARY 2002

DECLARATION

I, **Adewusi, Babatunde O.** of the Department of Architecture, School of Post Graduate Studies, Federal University of Technology, Minna hereby declare that this thesis work has been a personal academic undertaking executed under the supervision of my supervisor. All information utilized and their sources have been duly acknowledged

Adewusi, B.O

CERTIFICATION

This thesis titled MARINE MUSEUM, UNIVERSITY OF LAGOS by Adewusi, B. O, meets the regulations following the award of degree of Masters of Technology in Architecture and is approved for its contribution to knowledge and literary presentation.

	22-05-02
Supervisor	Date
	23/5/02
Head of Department	Date
External Examiner	Date
Dean, School of Post Graduate Studies	Date

DEDICATION

This is dedicated fully to GOD for HIS Grace and Mercy endureth forever.

ACKNOWLEDGEMENT

If I said nobody contributed to the success of this thesis, I would be lying. And if I said there is no need to recognize the effort of some particular persons or people, I would be most ungrateful.

I would like to say a big thank you to my supervisor Arc. Olagunju for your patience, ideas, and support even when I did not deserve it. Thank you sir. And my H.O.D, Arc. (Mrs.) Zubairu, thank you Ma for your meticulous leadership. May God grant you more wisdom in leading and relating with people of various mentalities. I would like to thank and appreciate Dr. (Mrs.) Christie Ogunwemimo who lectures in the Department of Micro Biology, University of Lagos and Dr. Sadiku H.O.D of the Department of Fisheries, Federal University of Technology Minna. Thank you so much Ma and Sir for your assistance for the understanding of this project came through you.

Daddy, mummy, what more can I say than thank you both so much for everything. It is only God that an reward you both for what you've done. Even though I am your responsibility, your reward from God is sure. "Egbon, e she", Fola, Kole, thanks for your support. If I did not have you as my family, I would have been incomplete. Seyi Adewusi, same goes for you.

Pastor Joshua, Mama, thank you so much for taking care of me through out this period. Pastor Ita (daddy), thank you for your prayers and spiritual support. And yo'all that are in pastor's house, Lady Grace, Sheila, Bro. Charles, Matthew, Dora, Laura, Data, Christie and the little ones, Tope, Jenom and little Jammaima, keep your head up.

'Yo, to all my course mates, propps to yo'all and thanks for being my course mates. See yo'all "at the top".

Uche, brother, thanks for your suggestions. Jeremiah you deserve to be mentioned here since I forgot to mention your name in my B.tech project, and more so, thanks for your contributions. Undubisi thanks for the typing assistance, and you Chuxy, you do well.

Easy Mcreal, ...a'why

Vocke, ... 'Why

Lanre Oklan, ... "Propps" to you

Tobby, ... tumbs-up

And after all is said and said and said and done, we'll be the victorious ones.

To everyone that has contributed to the success of this thesis write-up in one-way or the other, I'm saying a big thank you once again and may your will and heart desire coincide with God's and may it be fulfilled according to God's will. Amen.

ABSTRACT

In reaching a functional proposal for this design project, necessary precautions must be taken in the siting of the proposal. It is necessary to locate the site close to a natural water body that will enhance and maintain marine life. It is also required that in siting such a facility, the natural water body must have adequate and necessary marine life which would create variety, easy monitoring of the natural habitat and maintenance of the same natural habitat that would help achieve the purpose of the study.

When mounting aquariums, the water life that is to be catered for must be properly understood and so in essence, the water pH and content must be that which is acceptable to the same water life. The water be must have necessary features that exit in the natural habitat; as much as possible, making the artificial habitat not any different from the natural habitat. If the natural habitat requires rocks at the waterbed, then it must be maintained in the aquarium. Since some fishes feed on mosquito larvae that can be found beneath natural water plants on the waterbed, and since some require the same natural plants for necessary life cycle within the habitat, then such provisions must be made when considering the use of aquariums.

Since the buildings that are going to be erected on site will most likely be on soil with high water table, the effect of water on such buildings must be curtailed by necessary treatment of the walls, floor slabs and foundation.

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CHAPTER ONE

INTRODUCTION

The tourist industry in our country, Nigeria, is one, which has been neglected in favour of other sectors like the industrial, education etc. However, in thee last 2 decades, there has been a rather futile attempt to wake the sleeping sector with the creation of amusement parks, night clubs, beaches and resorts, perhaps created in a bid to acknowledge the existence of the tourism sector. One fact that had not been realized however is that tourism and indeed recreation, is a major part of education. If this fact is known and acknowledged, there will definitely be a different response to the need for recreation in Nigeria. In the last 5 years there has been a surge in the occurrence of stress-related diseases and mental illnesses, all partly as a result of the lack of decent, well-organized affordable and educative recreational activities.

"Tourism comprises 2 major parts' – the tourist and the spectacle of interest which can be either the actual spectacle or the facilities needed to support its appreciation. The spectacle of interest must be enhance enough to catch the attention of the tourist and educative enough to maintain his interest.

Taking Nigeria as a case study with reference to museums in particular, we find that the scope in museum development and appreciation is indeed very narrow. History museum housing traditional mask and others indigenous artifacts abound in almost every state in Nigeria, a few exception being the museum in the Nigeria ammunition and war – related equipment, as well as the museum of Natural and traditional Art (MOTNA) in Jos. In America alone, there are museums of nearly every object available in this world, one of them is the Bared Wire museum in La Crosse, Kansas, where an exhibition of about700 types of bared wire is displayed as well as

It is hope that this research paper will highlight yet another unexplored area of tourism, which is already so common especially in, developed countries in the world, encouraging a broader and more challenging outlook to tourism development in Nigeria.

All necessary information used in this thesis was sourced from books, the Internet and personal interview with professionals in the field.

strands from the Berlin wall, wire cutting tools and antique medicine bottle whose contents were use to repair damaged bared wire. Another is the tragedy in St. Augustine, Florida, which houses the car from which former president of the U. S. A, J. F. Kennedy was shot. Yet another is the hamburger hall of fame in Seymour, Wisconsin which housed models of nearly every type of hamburger available, the museum of incandescent lighting at Baltimore, Maryland which holds 8,500 different types of bulbs including the largest and the smallest light bulb every model Hence we can easily conclude that the lack of variety is our museum and consequently our tourism would stems from a lack of ability to think internationally and this must be developed if any progress is to made in the tourism industry.

1.1 AIMS AND OBJECTIVES

The proposal for a marine museum at the university of Lagos Lagoon front tourist centre, is basically to fulfill, first a recreational need in the university community and ultimately, to further develop the tourist industry in Nigeria by introducing an uncommon tourist facility with regards to Nigeria, which will automatically necessitate the need for alliance with similar recreational facilities abroad.

Aims

- To provide alternative answer to the problems faced by the tourism centre in Nigeria.
- To provide a knowledge enhancing and research challenging source of recreation for the university community and the public.
- To serve as a money generating venture for the department managing it as well as the university body.

Objective

- To achieve the desired aim of this project, the following objectives have been adopted.
- Provision of laboratories for research work to be carried out.
- Ticket sales stand to be located at the entrance porch of the aquarium hall.
- The use and maintenance of natural features like lagoon, rocks. To create a natural atmosphere and bring about harmony between the building, the environment and the aqua-life to be exhibited.

1.2 RESEARCH METHODOLOGY

Avenues used to obtain information so as to achieve a proper design proposal includes: journals, magazines, interviews to lecturers and professionals in the departments and offices that would help provide meaningful information with regards to the design proposal e.g. lecturers in the department of Marine Biology in the University of Lagos, Case studies, Site investigation and the internet.

1.3 SCOPE AND LIMITATION OF WORK

Scope:

The scope of the design as to establish a marine museum for the exhibition of marine life. Facilities within the same setting includes

- Aquarium exhibit hall
- Laboratories
- Libraries
- Craft exhibition gallery
- Natural and artificial ponds
- Restaurant

- Conference hall
- Auxiliary facilities such as generator house, aerator house, gatehouse, toilet, stair-well, water tanks, pumping room, stores, gazzebo.

Limitations

Time constraint, financial consideration, lack of sufficient data due to the nature of the project are major factors militating against the comprehensiveness of this work. However, I tried my best to make use of all the information that were at my disposal.

1.4 IMPORTANCE OF STUDY

If the purpose and goals of this study are achieved, it will be a conscious attempt by architecture to bring harmony between the natural features and inculcating them into architectural design by resolving both sea life and their habitat.

1.5 DEFINITION OF TERMS

Pertaining to the study, it is likely to encounter professional words and terms such as:

aquarium:- A building that facilitates and display aquatic animals in aquarium tanks for recreation and may be research purposes.

museum:- A building or place for the keeping, exhibiting and study of objects of scientific, artistic and historical interest.

Marine: -

Brackish water: - A body of natural water whose ph changes (sometimes fresh water and sometimes salty water) depending on the season and time of the year.

Fresh water: -A body of natural water, which the ph is between 6.5 and 7.5.

Seawater: -A body of natural water having ph that lies between 11.5-13.5.

CHAPTER TWO

LITERATURE REVIEW

2.1 MUSEUM

This is an institution that acquires, preserves, display, and interprets an encyclopedic range of objects. Concerned with both the natural world and artifacts, Museums cover such varied fields as art and aeronautics, religion and sports, biology and music. Educational and recreational, they seek to serve both scholars and the general public. By the authenticity of their contents and their appeal to the eyes, museums have the power to stimulate thinking and engage emotions. They may be considered purveyors of truth and leaders in improving the quality of life.

2.1.1 TYPES OF MUSEUMS

Museums fall into three main categories, which are history, art and science. The categories may overlap, and they are much subdivided. Open- air museums cut across categories.

History museums are the most numerous. They may survey the history of a nation for example, the Museo Nacional de Historia in Mexico City and the Hungarian National Museum in Budapest. More Limited in scope are regional museums, Local historical societies, and museums of city history, such as those in Amsterdam, Warsaw, and new York. The houses of famous persons and other period buildings either preserved and restored on site as in Newport, R.I., or grandiosely reconstructed as was colonial. Williamsburg, Va., may also be considered history museums. So are archaeological, anthropological, and historical sites, such as Roman ruins in Bath, England, pueblo Indian cliff dwellings in the southwestern United States, the battlefields of waterloo in Belgium, and the humble peasant farms at Skansen (1891), near Stockholm, the first permanent autdoor museum. Anthropology museums, such as the Museo Nacional de Antropologia in Mexico City, have historical, scientific, and artistic aspects.

Art museums are collections not only of the "fine arts" of sculpture and painting of high civilizations but also of decorative and folk arts and the arts of nonliterate peoples. Among the great national museums of fine arts are the Louvre in paris, the Prado in Madrid, the Uffizi in Florence, and the Hermitage in Leningrad. Some fine-art museums specialize in one period or culture –for example, the Musee de Cluny in paris for medieval art, the Guggenheim in New York City for modern art, and Asia House in New York City for Oriental art. The Victoria and Albert Museum in London covers worldwide decorative arts, while the Corning Museum in Corning, N.Y., specializes in glass. Folk –art museums, sometimes considered history museum, can frequently be seen in Europe. A unique art museum is the Museum of Images of the Unconscious in Rio de Janeiro, which displays works by mental patients.

Science museums cover both the pure and applied sciences, although some museums of technology may be considered historical. The category of pure-science museums includes museums of natural science, containing collections of rocks, plants, skeletons, and mounted animal specimens-for example, the British Museum (Natural History), London; the Natural History Museum. Vienna, and the Field Museum, Chicago. Also included are planetariums, aquariums, zoos, botanical gardens, and arboretums.

Outstanding among general museums of applied science are the Science. Museum; London, the Deutsches Museum; Munich, and the Museum of Science and Industry, Chicago. Among museums devoted to more specialized aspects of man's economy and technology are the Cleveland (Ohio) Health Museum; the whaling Museum New Bedford, Mass.; the Railway Museum, Leicester, England; and the Hungarian Agricultural Museum, Budapest.

2.1.2 MOTIVES FOR COLLECTING

A survey of the history and types of museums reveals a variety of motives, often combined, influencing man to invest talent, time, and money in assembling objects of no direct utilitarian value.

(1) Of primary importance is the age-old desire to expand the frontiers of knowledge. The 16 century Italian physician Ulisse Aldrovandi set himself the task of illustrating all nature in his private museum. Thomas Jefferson sent paleontogical specimens to France to counter the accusation of the 18th century French naturalist G.L.L Buffon that animals and peoples deteriorated when transplanted to America.

(2) Another strong motive is the urge to identify with a particular group. Thus Europeans since the Renaissance, admiring the achievements of classical Greece and Rome, collected antiquities from those civilizations. The attitude survives in the J. Paul Getty Museum, a reconstruction of a Roman villa, built in Malibu, calif., in the 1970's. Strengthening religions identity are museum of objects inspired by faith, such as the Tantra Museum in New Delhi and the Mennonite Village Museum in Steinbach, Canada.

National loyalty is encouraged by the reconstruction of a former polish royal residence in Warsaw, the National Museum of New Delhi, and the shahyad Arya

Mehr Monument, containing masterpieces of Iranian art, which marks the approach to Teheran. Museums in the USSR commemorating political and war heroes contribute to soviet patriotic feeling, and the National portrait Gallery in Washington, D.C., keeps alive the memory of noted Americans.

An outdoor museum of 11 distinct ethnic farmsteads in Eagle, Wis., expresses that state's loyalty to its immigrant heritage. In such countries as Vietnam, Thailand, and Bangladesh, "Living museums of ethnography" are raising citizens' consciousness of their ancient cultural past. The identity of black Americans is articulated by special exhibits such as "African Tribal Images at the Cleveland Museum of Art in 1968.

(3) Another impulse to collecting is the desire to prove success and gain prestige. Military conquerors frequently carried home art objects from subjugated lands as evidence of triumph and as status symbols.

Thus Roman soldiers filled their house with art objects plundered from Greece. Napoleon in 1798 ordered that works of art seized by his armies be paraded on the Champs de Mars in Paris before being deposited in the short-lived Musee Napoleon. In the late 19th century a desire for conspicuous collections of European art objects gripped American entrepreneurs who wished to display their financial success. There is still a tendency in some museums to take pride in the size and opulence of their buildings, not always to the benefit of visitors. The wish of a prestigious institution to secure at all costs a famous work of art contributes to the often fabulous prices paid for such works at auctions.

(4) Closely related to the motive of prestige is that of hoarding. Some collectors are infatuated with quantity. The Roman statesman Cicero, for example, filled 18 villas with treasures, and the son of the 19th century American collector

William Thompson Walters chartered a ship to convey his Italian paintings to Baltimore.

In a modern museum, of course, large numbers of objects may be less a matter of greed than a necessity for scholarly research.

(5) Finally there is the appeal of art objects to the senses and the emotions. According to the 16th century painter Francisco de Holanda, Paintings make sad people feel joy and let the contented discover misery ... they make us experience love ...pity." Art museums are concerned with these emotional faculties, which have been slighted in favor of cognition by formal academic education but which are now recognized as being just as much a part of the functions of the nervous system.

2.2 AQUARIUM

This is a tank or group of tanks for the display or study of fish or other aquatic animals. The basic requirement for keeping fish (except in small home aquariums) is to ensure the movement and treatment of large quantities of water, because the great majority of aquatic animals cannot endure the conditions that develop in small standing bodies of water. Particular requirements include filter- age clarification, temperature and chemical control, aeration, and storage. Most of these functions are performed in the operation of large aquariums, although the degree to which each is carried out may vary with local conditions. The limitation imposed by these requirements almost invariably cause any large aquarium to become a collection of relatively small tanks, each served by a circulation system isolated that of the other tanks.

It was once thought possible to by pass some of these requirements in certain areas. Thus, in 1938, an entirely different kind of aquarium, called an *oceanarium*, was built at St. Augustine, Fla. This consisted of two very large tanks, open to the sky- one circular, 75 feet (23 meters) in diameter, the other roughly rectangular, 100 by

40 feet (230 by 12 meters) and each about 15 feet (5 meters) deep. Each tank bad a number of glazed ports cut at various levels for viewing the fish. Water from the ocean was pumped directly into the tanks, and large populations of marine fish mammals, turtles, and a few birds were placed in each tank. A number of modifications in the operation of the tanks became necessary, however, so that these tanks are now aquariums in the conventional sense of the word.

The operation of a domestic aquarium follows different principles from those governing the operation of large, institutional aquariums. The small aquariums are, by their nature, limited in the kind and number of fish that they can carry. Such aquariums work on the principle that fresh water, uncles it is abused, overloaded, or poisoned will improve as it ages and continue to support any of the kinds of fish that can live in it in the first place.

2.2.1 HISTORY OF THE AQUARIUM

Keeping fish for amusement or for exhibits of ancient origin, goes back to at least 600 B.C, when the Sumerians practiced pond culture of fish. Later, the Chinese sea carp and goldfish, and the Roman of early historic times maintained pet marine fish, spending considerable efforts and money to arrange for constant changes of water by means of channels cut from the sea to their ponds. The use of glass-sided tanks as we know them today, containing both fish and plants, started in Britain about the middle of the 19^{th} century.

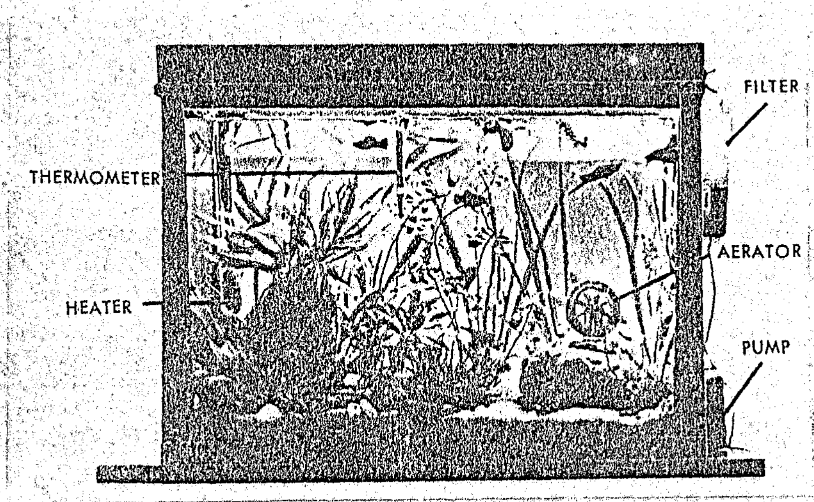
In 1853, soon after the development of home fish keeping the Zoological Gardens of Regent's Park, London, England, put a collection of standing water tanks into a small building called the fish House, which became the first established public aquarium. Several other cities in England and on the Continent established aquariums within the next few years, but the difficulties inherent in the keeping of any fish other than the hardiest and most tolerant soon caused them al to close. However, several principles were becoming understood, and they were used in a new aquarium in Blackpool, England, in 1871, and in Brighton, England, and Frankfurt, Germany, in 1872. These were the first large public aquariums like those of today.

P.T. Barnum opened the first public aquarium in the United States in New York City in 1856. Like its English contemporaries, it did not last long, for it had all the faults of the English aquariums. There were very few aquariums in the United States until New York City opened its aquarium in 1896 at the remodeled fort Castle Garden (formerly Castle Clinton). This aquarium was the largest in the world for many years and, until it closed in 1941, was a leader in the development of aquarium management practices. The first stage of a new New York Aquarium was dedicated on June 5, 1957, on the oceanfront at Coney Island, Brooklyn. The exhibitions consist mainly of marine mammals in an oceanarium type of tank and of tropical reef fishes, marine reptiles, and birds. Other oceanarium type aquariums are the Marine lands of Florida, in St. Augustine, and the Pacific on the Palos Verdes Peninsula near Los Angeles.

2.2.2 STOCKING THE AQUARIUM

In stocking a public aquarium or oceanarium, the animals first must be caught unharmed and then transported safely to their destination. This move also involves the transportation of water, which is as subject to deleterious change as is water in the aquarium.

A major fallacy once governed the stocking of small fish tanks. This was the principle of the so-called "balanced aquarium'. The theory was that aquatic plants could take up the carbon dioxide released by the fish and use this carbon dioxide to release the oxygen needed by the fish. This simple principle gained widespread acceptance until it was shown that only under very strong light would the plants release oxygen. At other times, the plants actually competed with the fish for the available oxygen, which was entering the water through its surface. In actual practice, a small planted tank, in comparison to a similar unplanted tank, under normal conditions will carry more fish per unit of water only if kept in bright light continuously, day and night.



2.2.3 AQUATIC PHYSIOLOGY AND AQUARIUMS

By their nature, fish and aquatic invertebrates are more intimately bound to their environment than are terrestrial animals. Proportionately, aquatic animals have less blood than terrestrial animals for instance, because they are in osmotic balance with the water surrounding them (the concentration of salts in their blood is the same as the concentration in the surrounding water solution). Consequently, the aquatic environment must be more closely controlled both in temperature and in chemical conditions than either of these need be for terrestrial creatures. Also, noxious animal wastes slowly change the water chemistry; if allowed to accumulate, the wastes will kill the aquarium's inhabitants.

In aquariums or oceanariums where ocean where ocean water is pumped into tanks and retuned to the sea, and where the inhabitants are from local. Water much less control is needed than in land aquariums. In these aquariums, water originally transported from the sea must be stored and continually re-circulated.

Even in controlled aquariums, control of algae is a prime necessity because the metabolites developed by higher organisms and by slight stimulate a prolific growth of algae that not only limit visibility but also would algae is to use copper, an excellent decide. Unfortunately, many fish and inveterate can tolerate a far smaller proportion of upper than is needed to destroy the algae.

A considerable financial saving in maintaining fresh aquarium water is possible with the algae of fairly suitable synthetic seawater. These are somewhat more limited than natural seawater in the kind of fish that will support. Synthetic seawater is prepared by adding to fresh water the proportions of most of the animals normally present in seawater. Some and aquariums use a mixture of natural and synthetic seawaters to save money.

There are many other methods for the command of tank water and for the moving of aquatic animals. Most are the result of the experience of the workers in some specific aquarium, but variations are numerous.

2.2.4 FUNCTION AND PURPOSE

Early aquariums were considered to be special museums, but their recreational appeal was soon recognized and developed, publicly owned aquariums are primarily educational institutions. Privately owned ones, varying in size from small one-man operations to huge oceanariums, however, also frequently provide educational programs and exhibits; for example, the oceanariums pioneering in the capture, care, and training of dolphins and whales have increased public awareness of their importance. Some aquariums built for research are not always open to the public.

Closely related to aquariums is the raising of fishes and invertebrates to provide food or stock for sport fishing. This is now usually termed aquaculture or aquiculture. The management of ornamental ponds may also serve a useful purpose, particularly since filtration and water treatment are sometimes used to improve, pond-water quality. Such ponds may be small garden pools, primarily for water lilies, or larger ponds on farms for the culture of food fishes.

Design and Architecture

The first containers specifically designed for aquatic specimens were the strictly functional open-air tanks used by the Romans to preserve and fatten fish for market.

It was not until the 18th century that the importation of goldfish into France from the Orient for aesthetic enjoyment created the demand for small aquariums; ceramic bowls, occasionally fitted with transparent sections, were produced. The large public aquariums in many European cities, built between 1850 and 1880, were influenced by current romanticism, and conscious efforts were made to create the illusion that the spectator was entering into the underwater world. More recently, the trend has been to emphasize the natural beauty of the specimens and to make a sharp distinction between the water and the viewing space.

Basic materials. Regardless of size-whether a small jar with a capacity of less than one gallon or a huge tank with a capacity of more than 1,000,000 gallon-aquariums must be constructed with care; many substances, especially plastics and adhesives, nontoxic to humans, are toxic to water-breathing animals.

Glass is probably the safest basic material, although polyethylene, polypropylene, acrylic plastics (plexiglass), and fluorocarbon plastics are normally nontoxic. Fiberglass has been widely used and is nontoxic if properly prepared. Adhesives for sealing include epoxy resins, polyvinyl chloride, silicone rubber (except for certain coloured preparations), and neoprene. Metals are not usually used, especially in seawater, which is highly corrosive. Stainless steel, which has a low toxicity, is often used, especially in freshwater systems.

The tank. A small aquarium can be constructed entirely of glass and without supporting frames by using silicone rubber as an adhesive. Fibreglass is probably the most practical supporting material for all but the largest tanks since it is lightweight, strong, does not deteriorate, and is easily fabricated into any shape. Wood, though widely used, is subject to rot and boring organisms and thus must be protected. Reinforced concrete, including special mixes for seawater, is the principal supporting material used in the construction of large aquariums.

In modern aquariums tanks of a variety of sizes and shapes are often grouped into discrete units in order to avoid the "boxes of fish" look that characterizes some of the older, formal aquariums. Dry dioramas at the rear of the tank create illusion of distance; the tank habitat can be a natural one or one in which fibre has been impregnated or pained to duplicate almost any environment. Modern aquariums attempt displayed.

Polished plate glass fully tempered polished plate glass, and plexiglass are the most commonly used glazing materials. Polished plate glass is usually used only in small aquariums because it breaks into large pieces when it fails. One generally accepted practice is to glaze large tanks with two or three layers of tempered glass so that if breakage occurs to one layer. Although plexiglass is easily scratched, it can be repolished.

Accessories. Accessories for individual tanks normally include filters, air pumps, lights, and electric thermostatically controlled immersion heaters, or perhaps alternately, some means of chilling the water. In aquarium buildings the tank are usually grouped so that they have a common filter and method of temperature control. Water sterilizers may be included. Plumbing in large aquarium with multiple systems is sometimes complex, involving a variety of automatic controls and water-quality monitoring systems. Because of its cost and fragility, glass plumbing (e.g for aeration or circulation of water within an aquarium) is used only in cases in which low toxicity is essential. Unplasticized polyviny1 chloride pipe is widely used. Fibreglass pipe and epoxy-lined asbestos pipe are sometimes used, but lead and hard rubber pipe are obsolete. In seawater systems the growth of fouling organisms such as mussels and barnacles is avoided by providing the with duplicate pipes and alternating their use on a weekly basis. When a line is dry the few organisms present die and are flushed out when the line is again put into service.

Nonmetallic or plastic-lined pumps are better than metal ones in-terms of toxicity, but stainless steel is often satisfactory. Airlift pumps (such as those used in home aquarium subsand filters) move large volumes of water when the lift pipes are of sufficient diameter.

Generally, the most effective illumination is by incandescent lamps placed above the front glass. Fluorescent lights provide even illumination but may over-illuminate the tank wall; coloured lights accentuate natural colours; and mercury-vapour lamps encourage maximum growth of marine plants.

Plants. The introduction of some form of aquatic plant life is of practical value in an aquarium, although the presence of plants can cause complications. Aquatic plants consume dissolved oxygen and give off carbon dioxide; under the influence of bright light, plants also consume carbon dioxide and give off oxygen while engaged in photosynthesis. This operates very well so long as light of a certain intensity falls on the plants-the animals thus give off what the plants can use and vice versa. Aquariums in which the plants and animals are believed to balance each other in a respiratory sense are generally referred to as balanced aquariums. This condition of balance is rarely attained, however because under certain conditions (i.e, inadequate light intensity) the plants are in direct respiratory competition with the animals. Moreover, the atmosphere constantly enters the picture, affecting the exchange of gases through the water surface. The quantities of animal and plant life should be so related to the surface area of the tank that they can survive indefinitely by means of gaseous exchange through the surface film. There is an additional relationship between plants and animals in such an aquarium: the waste products of the fishes form fertilizer or food for the plants and are consumed by them. It is, strictly speaking, such water that aquarists consider conditioned and most suitable for the specimens of interest. Furthermore, dense, slow-growth plants that consume much of the waste of relatively few fishes as fast as they are formed usually furnish the most stable and attractive aquariums. A variety of such plants is available.

Maintenance problems

The design of a large aquarium must take into account the requirements of the specimens, especially since exhibits at modern aquariums include all types of aquatic organisms: mammals, birds, reptiles, amphibians, and invertebrates as well as fishes. Among the many factors that must be considered are traffic flow patterns of visitor, reflections off glass, and acoustics; and tank-maintenance problem such as water clarity, dissolved wastes, temperature tank docor, disease treatment and nutrition.

Water quality. The primary requirement for maintaining aquatic organisms is water quality. The water supply must be free of pollutants, including sewage and industrial wastes, and it should be in gaseous equilibrium with the atmosphere to ensure adequate oxygen and to avoid super-saturation with nitrogen. In re-circulating systems, water treatment must not only ensure clarity of the water but also purification of metabolic wastes. The source of freshwater is usually water supplies from which chlorine and other addition have removed, either by carbon filtration or by the addition of a chemical. Marine organisms can be maintained in either natural or artificial seawater; the latter has the advantage of being initially free from disease organisms and pollutants but may not be as suitable for some organisms.

There are three basic types of water systems: open, closed, and semi closed. In open systems the water flows through the aquarium once and is discarded. This provides water quality comparable to that of the natural environment and there is no building of toxic metabolic waste; however, temperature control and pumping are usually costly, and filtration often is necessary.

Water is continuously re-circulated in closed systems and is only renewed periodically. Metabolic wastes must be treated since they are not continuously flushed from the system. An important problem is that ammonia must be rapidly removed or transformed because it is harmful even at very low concentrations. In the aquarium the bacteria that convert ammonia to nitrite reside primarily in the filter material, and a slow sand filter with a large surface area is usually provided to ensure their abundance. Plant growth in the aquarium, especially in marine systems, is not usually sufficient to utilize all the nitrate produced by bacteria from nitrite. Although some aquariums have operated many years with a minimum of water renewal, it is normally necessary to replace from 1 to10 percent of the water per month to maintain a low level of nitrites. The use of charcoal in both freshwater and seawater systems helps to slow the accumulation of nitrogenous wastes. Metabolic wastes also cause an increase in the acidity of the water. Carbonate compounds are commonly used to maintain an optimal level of acidity, particularly when water renewal is frequent.

Semi-closed system are essentially the same as closed except that there is a constant connection to the water supply, and the problem of dissolved wastes is system is less costly than the open one with regard to temperature control and pumping.

The turnover rate, or rate of water replacement, of individual aquarium is important and should be no more than two hours. In addition, aeration by means of air stones (diffusers) should be provided to guard against asphyxia in the event of an unexpected water-supply failure.

Fishes and invertebrates also be maintained without filtration or aeration in aquarium that are "balanced" with plants; however the balance between plants and animals is very difficult to attain on a large scale or even in a normally stocked aquarium, especially a seawater aquarium.

Freshwater pools for mammals and birds present special problems. They generally require a higher filtration rate greater filter capacity because they accumulate large amounts of fecal wastes. Air-breathing animals, however, are not highly sensitive to water quality; thus chemical treatments, such as chlorination, which would kill fishes, can be used to control bacteria and to improve water clarity. Seawater are simpler; for example, a 2percent sodium chloride solution will satisfactorily maintain whales and dolphins. Seals and sea lions have been kept in freshwater, but this may increase their eye problems because of the osmotic effect of the freshwater on the eye tissues.

Feeding. The diet provided for aquarium specimens should approximate the natural diet as closely as possible. In addition to products available from the fish market, several commercially prepared diet and various live foods are available to the professional and home aquarist. As a general rule fishes do better it provided with a varied diet. Brine shrimp (*Artemia*) are a convenient source of food and are available both as newly hatched larvae or adults, either alive, frozen, or freeze-dried. It should be noted, however, that they do not fill all of the nutritional requirements of many plankton-feeding fishes.

Disease. Disease prevention is a constantly strived for goal, since disease, once introduced into the aquarium, are often difficult to eliminate. Specimens therefore must be provided with water of suitable quality; the proper habitat, including protective cover if necessary compatible tank-mates; and an adequate diet.

of toxic metabolic waste; however, temperature control and pumping are usually costly, and filtration often is necessary.

Water is continuously re-circulated in closed systems and is only renewed periodically. Metabolic wastes must be treated since they are not continuously flushed from the system. An important problem is that ammonia must be rapidly removed or transformed because it is harmful even at very low concentrations. In the aquarium the bacteria that convert ammonia to nitrite reside primarily in the filter material, and a slow sand filter with a large surface area is usually provided to ensure their abundance. Plant growth in the aquarium, especially in marine systems, is not usually sufficient to utilize all the nitrate produced by bacteria from nitrite. Although some aquariums have operated many years with a minimum of water renewal, it is normally necessary to replace from 1 to10 percent of the water per month to maintain a low level of nitrites. The use of charcoal in both freshwater and seawater systems helps to slow the accumulation of nitrogenous wastes. Metabolic wastes also cause an increase in the acidity of the water. Carbonate compounds are commonly used to maintain an optimal level of acidity, particularly when water renewal is frequent.

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New specimens are usually quarantined for two or three weeks prior to placement in the display tanks.

Several categories of infectious disease can occur in aquariums. Protozoans are a common problem, especially those causing freshwater and marine white-spot disease. Few treatments have thus for been completely successful. The problem in marine aquariums is so severe that many facilities maintain in the water a very low close of copper sulfate as a preventive measure, despite its undesirability in terms of toxicity. Formalin and insecticides, although both toxic, are common treatments for the large parasites that attach themselves to fish. Treatments that necessitate handing the specimens are avoided if possible. Large fishes that must be handled arte usually anasthetized in order to reduce stress.

Ultraviolet sterilizer units can prevent the spread of disease in aquarium water systems if strategically placed and of sufficient capacity. Antibiotics should be used only if essential for the cure of a specific disease; indiscriminate use cannot only result in resistant strains of the disease-causing organisms but also in destruction of nitrifying bacteria.

Staff. A large aquarium requires many kinds of specialists, including engineers, accountants, animal trainers, educators, and biologists. The people in the field cannot obtain formal training; as a result, aquarium experience is gained largely on the job.

CHAPTER THREE

RESEARCH AREA

WATER AND BUILDINGS

Whether thrust against and into a building by a flood, driven into the interior by a heavy rain, leaking from plumbing, or seeping through the exterior enclosure, water can cause costly damage to a building. Consequently, designers should protect buildings and their contents against water damage.

Protective measure s may be divided into two classes: flood proofing and waterproofing. Flood proofing provides protection against flowing surface water, commonly caused by a river overflowing its banks. Waterproofing provides protection against pénetration through the exterior enclosure of buildings of groundwater, rainwater, and melting snow.

3.1 FLOODINGPROOFING:

A flood occurs when a river rises above an elevation, called flood stage, and is not prevented by enclosures from causing damage beyond its banks. Buildings constructed in a flood plain, an area that can be inundated by a flood, should be protected against a flood with a mean recurrence interval of 100 years

Major objectives of flood proofing are to protect fully buildings and contents from damage from a 100-year flood, reduce losses from more devastating floods, and lower flood insurance premiums. Flood proofing, however, would be unnecessary if buildings were not constructed in flood plains. Building in a flood plain should be avoided unless the risk to life is acceptable and construction there can be economically and socially justified.

Some sites in flood plains possess some ground high enough to avoid flood damage. If such sites must be used, buildings should be clustered on the high areas. Where such areas are not available, it may be feasible to build up ban earth fill, with embankments protected against erosion by water, to raise structures above flood levels. Preferably, such structures should not have basements, because they would require costly protection against water pressure.

An alternative to elevating a building on fill is raising it on stilts (columns in an unenclosed space). In that case, utilities and other services should be protected against damage from flood flows. The space at ground level between the stilts may be used for parking automobiles, if the risk of water damage to them is acceptable or if they will be removed before floodwaters reach the site.

Buildings that cannot be elevated above flood stage should be furnished with an impervious exterior. Windows should be above flood stage, and doors should seal tightly against their frames. Doors and other openings may also be protected with a flood shield, such as a wall. Openings in the wall for access to the building may be protected with a movable flood shied, which for normal conditions can be stored out of sight and then positioned in the wall opening when a flood is imminent.

To prevent water damage to essential services for buildings in flood plains, important mechanical and electrical equipment should be located above flood level. Also, auxiliary electric generators to provide some emergency power are desirable. In addition, pumps should be installed to eject water that leaks into the building.

Furthermore, unless a building is to be evacuated in case of flood, an emergency water supply should be stored in a tank above flood level, and sewerage should be provided with cutoff valves to prevent backflow.

3.2 WATERPROOFING:

In addition to protecting buildings against floods, designers also should adopt measures that prevent groundwater, rainwater, snow, or melted snow from penetrating into the interior through the exterior enclosure. Water may leak through cracks, expansion joints or other openings in walls and roofs, or through cracks around windows and doors. Also, water may seep through solid but porous exterior materials, such as masonry. Leakage generally may be prevented by use of weather-stripping around windows and doors, impervious water stops in joints, or calking of cracks and other openings. Methods of preventing seepage, however, depend on the types of materials used in the exterior enclosure.

Definitions of Terms Related to Water Resistance

Permeability: Quality or state of permitting passage of water and water vapor into through, and from pores and interstices, without causing rupture or displacement.

*Excepted with minor revisions from Sec. 12 of the third edition of this handbook, authored by Cyrus C. Fish burn, formerly with the Division of Building Technology, National Bureau of Terms used in this section to describe the permeability of materials, coatings, structural elements, and structures follow in decreasing order of permeability:

Pervious or Leaky: Cracks, crevices, leaks, or holes large than capillary pores, which permit a flow or leakage of water, are present. The material may or may not contain capillary pores.

Water resistant: Capillary pores exist that permit passage of water and water vapor, but there few or no openings larger than capillaries that permit leakage of significant amounts of water.

Water repellent: Not "wetted" by water; hence, not capable of transmitting water by capillary forces alone. However, the material may allow transmission of water under pressure and may be permeable to water vapor.

Waterproof: No openings are present that permit leakage or passage of water and water vapor; the material is impervious to water and water vapor, whether under pressure or not.

These terms also describe the permeability of a surface coating or a treatment against water penetration, and they refer to the permeability of materials, structural members, and structures whether or not they have been coated or treated.

3.2.1 PERMEABILITY OF CONCRETE AND MASONRY:

Concrete contains many interconnected voids and openings of various sizes and shapes, most of which are of capillary dimensions. If the larger voids and openings are few in number and not directly connected with each other, there will be little or no water penetration by leakage and the concrete may be said to be water-resistant.

Concrete in contact with water not under pressure ordinarily will absorb it. The water is drawn into the concrete by the surface tension of the liquid in the wetted capillaries.

Water-resistant concrete for buildings should be a properly cured, dense, rich concrete containing durable, well-graded aggregate. The water content of the concrete should be a slow as is compatible with workability and ease of placing and handling. Resistance of concrete to penetration of water may be improved, however, by incorporation of water-repellent admixture in the mix during manufacture.

Water-repellent concrete is permeable to water vapor. If a vapor-pressure gradient is present, moisture may penetrate from the exposed face to an inner face. The concrete is not made waterproof (in the full meaning of the term) by the use of an integral water repellent. Note also that water repellents may not make concrete impermeable to penetration of water under pressure. They may, however, reduce absorption of water by the concrete.

Most masonry units also will absorb water. Some are highly pervious under pressure. The mortar commonly used in masonry will absorb water too but usually contains few openings permitting leakage.

Masonry walls may leak at the joints between the mortar and the units, however. Except in single-leaf walls of highly pervious units, leakage at the joints results from failure to fill them with mortar and poor bond between the masonry unit and mortar. As with concrete, rate of capillary penetration through masonry walls is small compared with the possible rate of leakage.

Capillary penetration of moisture through above-grade walls that resist leakage of wind-driven rain is usually of minor importance. Such penetration of moisture into well-ventilated sub grade structures may also be of minor importance if the moisture is readily evaporated. However, long-continued capillary penetration into some deep, confined sub grade interiors frequently results in an increase in relative humidity, a decrease in evaporation rate, and objectionable dampness.

3.2.2 ROOF DRAINAGE:

Many roof failures have been caused by excessive water accumulation. In most cases, the overload that caused failure was not anticipated in design of those roofs, because the designers expected rainwater to run off the roof. But because of inadequate drainage, the water ponded instead.

On flat roofs, ponding of rainwater causes structural members to deflect. The resulting bowing of the roof surface permits more rainwater to accumulate, and the additional weight of this water causes additional bowing and collection of even more water. This process can lead to roof collapse. Similar conditions also can occur in the valleys of sloping roofs.

To avoid water accumulation, roofs should be sloped toward drains and pipes that have adequate capacity to conduct water away from roofs, in accordance with local plumbing codes. Minimum roof slope for drainage should be at least ¼ in /ft, but larger slopes are advisable.

The primary drainage system should be supplemented by a secondary drainage system at a higher level to prevent ponding on the roof above the level. The overflow drains should be at least as large as the primary drains and should be connected to drain pipes independent of the primary system. The roof and its structural members should be capable of sustaining the weight of all rainwater that could accumulate on the roof if part or the primary drainage system should become blocked.

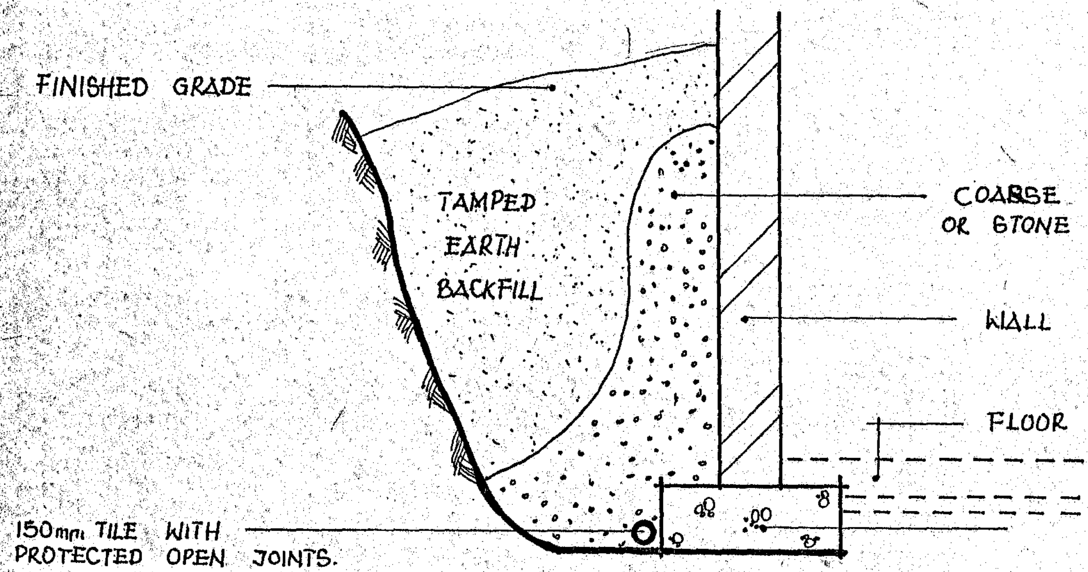
3.2.3 DRAINAGE FOR SUBGRADE STRUCTURES:

Subgrade structures located above ground-water level in drained soil may be in contact with water and wet soil for periods of indefinite duration after long-continued rains and spring thaws. Drainage of surface and sub-surface water, however, may greatly reduce the time during which the walls and floor of a structure are subjected to water, may prevent leakage through openings resulting from poor workmanship and reduce the capillary penetration of water into the structure. If subsurface water cannot be removed by drainage, the structure must be made waterproof or highly water-resistant.

Surface water may be diverted by grading the ground surface away from the walls and by carrying the runoff from roofs away from the building. The slope of the ground surfaces should be at least ¼ inches/ft for a minimum distance of 10 ft from the walls. Runoff from high ground adjacent to the structure should also be diverted.

Proper subsurface drainage of ground water away from basement walls and floors requires a drain of adequate size, sloped continuously, and where necessary, carried around corners of the building without breaking continuity. The drain should lead to a storm sewer or to a lower elevation that will not be flooded and permit water to back up in the drain.

Drain tile should have a minimum diameter of 6 inches should be laid in gravel or other kind of porous bed at least 6 inches below the basement floor. The open joints between the tiles should be covered with a wire screen or building paper to prevent clogging of the drain with fine material. Gravel should be laid above the tile, filling the excavation well above the top of the footing. Where considerable water may be expected in heavy soil, the gravel fill should be carried up nearly to the ground surface and should extend from the wall a distance of at least 12 inches



DRAINAGE AT THE BOTTOM OF A FOUNDATION.

3.2.4 CONCRETE FLOORS ON GROUND:

These should preferably not be constructed in low-lying areas that are wet from ground water or periodically flooded with surface water. The ground should slope away from the floor. The level of the finished floor should be at least 6 in above grade. Further protection against ground moisture and possible flooding of the slab from heavy surface runoffs may be obtained with subsurface drains located at the elevation of the wall footings.

All organic material and topsoil of poor bearing value should be removed in preparation of the subgrade, which should have a uniform bearing value to prevent unequal settlement of the floor slab. Backfill should be tamped and compacted in layers not exceeding 6in in depth.

Where the subgrade is well-drained, as where subsurface drains are used unnecessary, floor slabs of residences should be insulated either by placing a granular fill over the subgrade or by use of a light weight-aggregate concrete slab covered with a wearing surface of gravel or stone concrete. The granular fill, if used, should have a minimum thickness of 5in and may consist of coarse slag, gravel, or crushed stone, preferably of 1-in minimum size. A layer of 3-,4-, or 6-inches-thick hollow masonry building units is preferred to gravel fill for insulation and provides a smooth, level bearing surface.

Moisture from the ground may be absorbed by the floor slab. Floor coverings, such as oil-base paints, linoleum, and asphalt tile, acting as vapor barrier over the slab, may be damaged as a result. If such floor coverings are used and where a complete barrier against the rise of moisture from the ground is desired, a two-ply bituminous membrane waterproofing should be placed beneath the slab and over the insulating concrete or granular fill. The top of the light weight-aggregate concrete, if used, should be troweled or bushed to a smooth level surface for the membrane. The top of the granular fill should be covered with a grout coating, similarly finished. (The grout coat ½ to 1inches thick, may consist of a 1:3 or a 1:4 mix by volume of portland cement and sand. Some 2/8 or ½ in maximum-sized coarse aggregate may be added to the grout if desired.) After the top surface of the insulating concrete or grout coating has hardened and dried, it should be mopped with hot asphalt or coal-tar pitch and covered before cooling with a lapped layer of 15-lb bituminous saturated felt. The fist ply of felt then should be mopped with hot bitumen and a second ply of felt laid and mopped on its top surface. Care should be exercised not to puncture the membrane, which should preferably be covered with a coating of mortar, immediately after its completion. If properly laid and protected from damage, the membrane may be considered to be a waterproof barrier.

Where there is no possible danger of water reaching the underside of the floor, a single layer of 55-lb smooth-surface asphalt roll roofing or a similar product of 55-lb minimum weight may be substituted for the membrane. Joints between the sheets should be lapped and sealed with bituminous mastic. Great care should be taken to prevent puncturing of the roofing layer during concreting operations. When so installed, asphalt roll roofing provides a low-cost and adequate barrier against the movement of excessive amounts of moisture by capillarity and in the form f vapor.

If a lightweight-aggregate insulating concrete slab is used, it is placed directly on the subgrade, the slab should have a minimum thickness of 4inches and a minimum compressive strength of 1500 psi. The coarse aggregate should not exceed 1inches in size. If the insulating slab is to be covered with a membrane, the slab should be permitted to dry after curing and before the membrane is placed. The wearing surface applied over the membrane should be at least 2½in and preferably 3in thick of 3000 psi concrete and should be reinforced with welded wire fabric weighing at least 40 lb per square. A 6x6 mesh of No.6 wire is suitable. If the concrete wearing slab is to be covered with an oil-base paint or a floor covering that is a vapor barrier, the slab should be in a thoroughly dry condition before it covered.

3.2.5 BASEMENT FLOORS:

Where a basement is to be used in drained soils as living quarters or for the storage of things that may be damaged by moisture, the floor should be insulated and should preferably contain the membrane waterproofing previously described. In general, the design and construction of such basement floors are similar to those of floor on ground.

If passage of moisture from the ground into the basement is unimportant or can be satisfactorily controlled by air conditioning or ventilation, the waterproof membrane need not be used. The concrete slab should have a minimum thickness of 4inches and need not be reinforced, but should be laid on a granular fill or other insulation placed on a carefully prepared subgrade. The concrete in the slab should have a minimum compressive strength of 2000 psi and may contain an integral water repellent.

A basement floor below the water table will be subjected to hydrostatic upward pressures. The floor should be made heavy enough to counteract the uplift.

A bituminous-filled joint between the basement walls and a floor over drained soil will prevent leakage into the basement of any water that may occasionally accumulate under the slab. Space for the joint may be provided by use of beveled siding strips, which are removed after the concrete has hardened. After the slab is properly cured, it and the wall surface should be in a s dry a condition as is practicable before the joint is filled to ensure a good bond of the filler and to reduce the effects of slab shrinkage on the permeability of the joint. Hot asphalt or coal-tar pitch may be placed in the joint after is sides have been primed with a suitable bitumen.

Monolithic Concrete Basement Walls: These should have a minimum thickness of 6in. Where insulation is desirable, as where the basement is used for living quarters, light weight aggregate, such as those prepared by calcining or sintering blast-furnace slag, clay, or shale that meet the requirements of American Society for Testing and Materials Standard C330, may be used in the concrete for basement walls is cast, form ties of an internal disconnecting type are preferable to twisted-wire ties. Entrance holes for the form ties should be sealed with mortar after the forms are removed. If twisted-wire ties are used, they should be sealed be cut a minimum distance of 1½inches inside the face of the wall and the holes filled with mortar.

The resistance of the wall to capillary penetration of water in temporary contact with the wall face may be increased by the use of a water-repellent admixture. The water repellent may also be used in the concrete at and just above grade to reduce the capillary rise of moisture from the ground into the superstructure walls.

Where it is desirable to make the wall resistant to passage of water vapor from the outside and to increase its resistance to capillary penetration of water, the exterior wall face may be treated with an impervious coating. The continuity and the resultant effectiveness in resisting moisture penetration of such a coating is dependent on the smoothness and regularity of the concrete surface and on the skill and technique used in applying the coating to the dry concrete surface. Some bituminous coatings that may be used are listed below in increasing order of their resistance to moisture penetration:

- Spray- or brush-applied asphalt emulsions.
- Spray- o brush applied bituminous cutbacks.
- Trowel coatings of bitumen with organic solvent, applied cold.
- Hot-applied asphalt or coal tar pitch proceeded by application of a suitable primer.

Cementitious brush-applied paints and grouts and trowel coatings of a mortar increase moisture resistance of monolithic concrete, especially if such coatings contain a water repellent. However, in properly drained soil, such coatings may not be justified unless needed to prevent leakage of water through openings in the concrete resulting from segregation of the aggregate and bad workmanship in casting the walls. The trowel coatings may also be used to level irregular wall surfaces in preparation for the application of a bituminous coating.

Basement Wall of Masonry Units: Water-resistant basement walls of masonry units should be carefully constructed of durable materials to prevent leakage and damage due to frost and other weathering exposure. Frost action is mot severe at the grade line and may result in structural damage and leakage of water. Where wetting followed by sudden severe freezing may occur, the masonry units should meet the requirements of the following specifications:

Building brick (solid masonry units made from clay or shale).
Facing brick (solid masonry units made from clay or shale).
Structural clay load-bearing wall tile.

Hollow load bearing concrete masonry units.

For such exposure conditions, the mortar should be a Type S mortar having a minimum compressive strength of 1800 psi when tested. For milder freezing exposures and where the walls may be subjected to some lateral pressure from the earth, the mortar should have a minimum compressive strength of 1000 psi.

Leakage through a n expansion joint in a concrete masonry foundation wall may be prevented by insertion of a waterstop in the joint. Waterstops should be of the bellows type, made of 16-oz copper sheet, which should extend a minimum distance of 6in on either side of the joint. The sheet should be embedded between wythes of masonry units or faced with a 2in thick cover of mortar reinforced with welded-wire fabric. The outside face of the expansion joint should be filled flush with the wall face with bituminous plastic cement.

Rise of moisture, by capillarity, from the ground into the superstructure walls may be greatly retarded by use of an integral water-repellent admixture in the mortar. The water-repellent mortar may be used in several courses of masonry located at and just above grade.

The use of shotcrete or trowel-applied mortar coatings, ¾in or more in thickness, to the outside faces of both monolithic concrete and unit-masonry walls greatly increases their resistance to penetration of moisture. Sure coatings cover and seal construction joints and other vulnerable joints in the walls against leakage. When applied in a thickness of 2in or more, they may be reinforced with welded-wire fabric to reduce the incidence of large shrinkage cracks in the coating. However, the cementitious coatings do not protect the walls against leakage if the walls, and subsequently the coatings, are badly cracked as a result of unequal foundation settlement, excessive drying shrinkage, and thermal changes.

Two trowel coats of a mortar containing 1 part Portland cement to 3 parts send by volume should be applied to the outside faces of basement walls built of hollow masonry units. One trowel coat may suffice on the outside of all-brick and of brick-faced walls.

The wall surface and the top of the wall footing should be cleansed of dirt and soil, and the masonry should be thoroughly wetted with water. While still damp, the surface should be covered with a thin scrubbed-on coating of Portland cement tempered to the consistency of thick cream. Before this prepared surface has dried, a 3/8in-thick trowel applied coating or mortar should be laced on the wall and over the top of the footing; a fillet of mortar may be laced at the juncture of the wall and footing.

Where a second coat of mortar is to be applied, as on hollow masonry units, the first coat should be scratched to provide a rough bonding surface. The second coat should be applied at least 1 day after the first, and the coatings should be cured and kept damp by wetting for at least 3 days. A water-repellent admixture in the mortar used for the second or finish coat will reduce the rate of capillary penetration of water through the walls. If a bituminous coating is not to be used, the mortar coating should be kept damp until the backfill is placed.

Thin, impervious coatings may be applied to the plaster coating if resistance to penetration of water vapor is desired. The plaster coating should be dry and clean b8efore the bituminous coating is applied over the surfaces of the wall and the top of the footing. Unless backed with a tier of masonry or a self-supporting layer of concrete, the bituminous coatings may fail, in time, to bond properly to the inner face of the masonry. They should not be used on the inner faces of the walls unless properly supported in position.

3.2.6 IMPERVIOUS MEMBRANE

There are water proof barrier providing protection against penetration of water by hydrostatic pressure and water vapour. To resist hydrostatic pre the membrane should be made continuos in the all and floor of the basement. It should also be protected from damage during building operation and should b laid by experienced workers under competent supervision. It usually consists of three or more alternate layers of hot, mopped-on asphalt or coal-tar pitch and plies of bituminous saturated felt or woven cotton fabric. The number of moppings exceeds the number of plies by one.

An alternative is a 1/16-6o 1/8-inches thick layer of butyl rubber or rubberized asphalt and plastic film, secured with a compatible adhesive. In installation, manufacturers' recommendations should be carefully followed.

Bituminous saturated cotton fabric is stronger and is more extensible than bituminous saturated felt but is more expensive and more difficult to lay. At least one or two of the plies in a membrane should be of saturated cotton fabric to provide strength, ductility, and extensibility to the membrane. Where vibration, temperature changes, and other conditions conducive to displacement and volume changes in the basement are to be expected, the relative number of fabric plies may be increased.

The minimum weight of bituminous saturated felt used in a membrane should be 13 lb per 100 ft. The minimum weight of bituminous saturated woven cotton fabric should be 10oz/yd.

Although a membrane is held rigidly in place, it is advisable to apply a suitable primer over the surfaces receiving the membrane and to aid in the application of the first mopped-on coat of hot asphalt or coal-tar pitch.

The number of plies of saturated felt or fabric should be increased with increase in the hydrostatic head to which the membrane is to be subjected. Five pies is the maximum commonly used in building construction, but 10 or more plies have been recommended for pressure heads of 35 ft or greater. The thickness of the membrane crossing the wall footings at the base of the wall should be no greater than necessary, to keep very small the possible settlement of the wall due to plastic flow in the membrane materials.

The amount of primer to be used may be about 1 gal per $100ft^2$. The amount of bitumen per mopping should be at least 4½ gal per 100 ft^2. The thickness of the first and last mopping is usually slightly greater than the thickness of the mopping between the plies.

The surfaces to which the membrane is to be applied should be smooth, dry, and at a temperature above freezing. Air temperature should be not less than 50°F. The temperature of coal-tar pitch should not exceed 3000°F and asphalt, 350°F.

If the concrete and masonry surfaces are not sufficiently dry, they will not readily absorb the priming coat, and the first mopping of bitumen will be accompanied by bubbling and escape of steam. Should this occur, application of the membrane should be stopped and the bitumen already applied to damp surfaces should be removed.

The membrane should be built up ply by ply, the strips of fabric or felt being laid immediately after each bed has been hot-mopped. One of several methods of laying the plies is the solid or continuous method, in which a portion of each strip of fabric or felt is in contact with the supporting base of the membrane. The lap of succeeding plies or strips over each other is dependent on the width of the roll and the number of plies. In any membrane there should be some lap of the top or final ply over the first, initial ply. The American Railway Engineering Association requires a minimum distance of 2inches for this lap. End laps should be staggered at least 24inches, and the laps between succeeding rolls should be at least 12inches.

For floors, the membrane should be placed over a concrete base or subfloor whose top surface is troweled smooth and which is level with the tops of the wall footings. The membrane should be started at the outside face of one wall and extend over the wall footing, which may be keyed. It should cover the floor and tops of other footings to the outside faces of the other walls, forming a continuous horizontal waterproof barrier. The plies should project from the edges of the floor membrane and lap into the wall membrane.

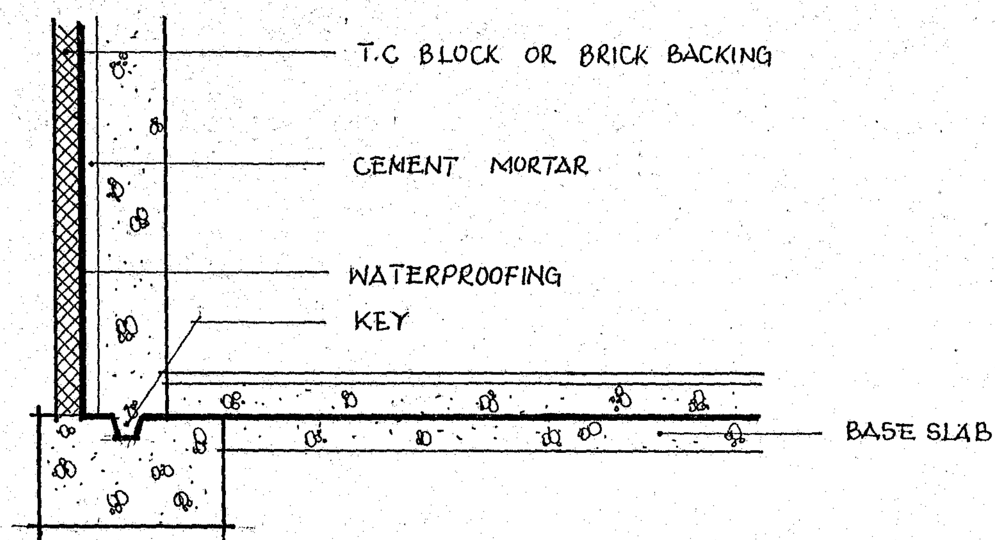
The loose ends of felt and fabric must be protected; one method is to fasten them to a temporary vertical wood from about 2ft high, placed just outside the wall face.

Immediately after the floor membrane has been laid, its surface should be protected and covered with a layer of Portland-cement concrete, at least 2inches thick.

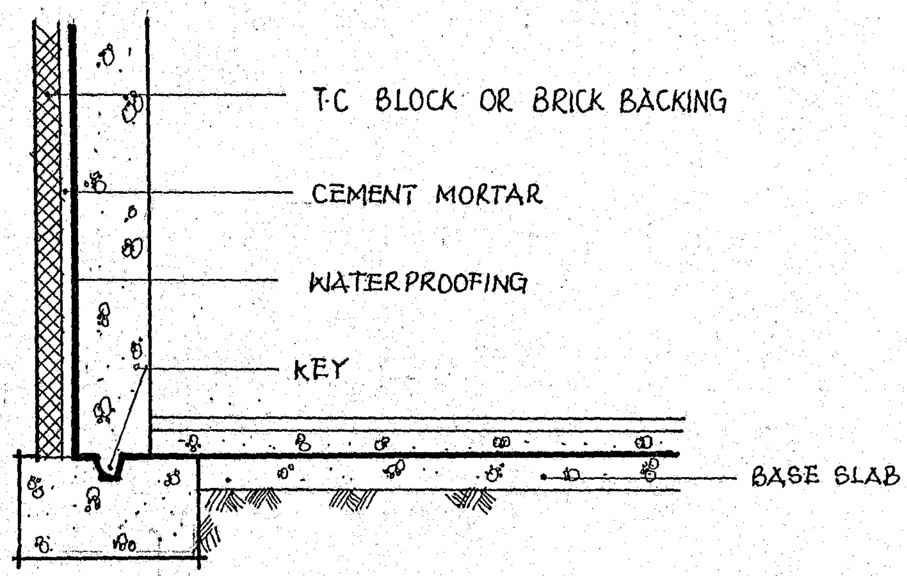
For walls, the installed membrane should be protected against damage and held in position by protection board or a facing of brick, tile, or concrete block. A brick facing should have a minimum thickness of 2½inches. Facings of asphalt plank, asphalt block, or mortar require considerable support from the membrane itself and give protection against abrasion of the membrane from lateral forces only. Protection against downward forces such as may be produced by settlement of the backfill is given only by the self-supporting masonry walls.

The kind of protective facing may have some bearing on the method of constructing the membrane. The membrane may be applied to the exterior face of the wall after its construction, or it may be applied to the back of the protective facing before the main wall is built. The first of these methods is know as the outside application; the second is known as the inside application.

METHODS OF APPLYING WATERPROOF MEMBRANES TO WALLS



(a) OUTSIDE APPLICATION (MEMBRANE APPLIED TO THE WALL, THEN PROTECTED BY THE BACKING).



(b) INSIDE APPLICATION (MEMBRANE APPLIED TO THE BACKING, AFTER WHICH THE WALL IS BUILT).

For the inside application, a protective facing of considerable stiffness against lateral forces must be built, especially if the wall and its membrane are to be used as a form for the casting of a main wall of monolithic concrete. The inner face of the protecting wall must be smooth or else leveled with mortar to provide a suitable base for the membrane. The completed membrane should be covered with a 3/8-inches-thick layer of mortar to protect it from damage during construction of the main wall.

Application of wall membranes should be started at the bottom of one end of the wall and the strips of fabric or felt laid vertically. Preparation of the surfaces and laying of the membrane proceed much as they do with floor membranes. The surfaces to which the membrane is attached must be dry and smooth, which may require that the faces of masonry walls be leveled with a thin coat of grout or mortar. The plies of the wall membrane should be lapped into those of the floor membrane.

If the outside method of application is used and the membrane is faced with masonry, the narrow space between the units and the membrane should be filled with mortar as the units are laid. The membrane may be terminated at the grade line by a return into the superstructure wall facing.

Waterstops in joints in walls and floors containing a bituminous membrane should be the metal-bellows type. The membrane should be placed on the exposed face of the joint and it may project into the joint, following the general outline of the bellows.

The protective facing for the membrane should be broken at the expansion joint and the space between the membrane and the line of the facing filled with a bituminous plastic cement.

Details at pipe sleeves running through the membrane must be carefully prepared. The membrane should be reinforced with additional plies and may be calked at the sleeve. Steam and hot-water lines should be insulated to prevent damage to the membrane.

3.2.7 ABOVE-GRADE WATER-RESISTANT WALLS:

The rate of moisture penetration through capillaries in above-grade walls is low and usually of minor importance. However, such walls should not permit leakage of wind-driven rain through openings larger than those of capillary dimension.

Walls of cellular concrete, made of aggregates containing no fines, are highly permeable and require surface coatings of grout or mortar to prevent leakage of wind-driven rain.

Precast-concrete or metal panels are usually made of dense, highly water-resistant materials. However, walls made of these panels are vulnerable to leakage at the joints. In such construction, edges of the panels may be recessed and the interior of vertical joints filled with grout or other sealant after the panels are aligned.

Calking compound is commonly used as a facing for the joints. Experience has shown that calking compounds often weather badly; their use as a joint facing creates a maintenance problem and does not prevent leakage of wind-driven rain after a few years' exposure.

The amount of movement to be expected in the vertical joints between panels is a function of the panel dimensions and the seasonal fluctuation in temperature and, for concrete, the moisture content of the concrete. For panel construction, it may be more feasible to use an interlocking water-resistant joint. For concrete, the joint may be faced on the weather side with mortar and backed with either a compressible premolded strip or calking.

Brick walls 4inches or more in thickness can be made highly water-resistant. The measures that need to be taken to ensure there will be no leakage of wind-driven rain through brick facings are not extensive and do not require the use of materials other than those commonly used in masonry walls. The main factors that need to be controlled are the rate of suction of the brick at the time of laying and filling of the joints with mortar

In general, the greater the number of brick leaves, or wythes, in a wall, the more water-resistant the wall.

Walls of hollow masonry units are usually highly permeable, and brick-faced walls backed with hollow masonry units are greatly dependent upon the water resistance of the brick facing to prevent leakage of wind-driven rain. For exterior concrete masonry walls without facings of brick, protection against leakage may be obtained by facing the walls with a cementitious coating of paint, stucco, or shotcrete.

For walls of rough-textured units, a Portland cement-sand grout provides a highly water-resistant coating. The cement may be either white or gray.

Factory-made Portland cement paints containing a minimum of 65%, and preferably 80%, Portland cement may also be used as a base coat on concrete masonry. The paints, stuccos, and shotcrete should be applied to dampened surfaces. Pneumatically applied coatings thinner than those discussed above and which contain durable, low-absorptive aggregates are also highly water-resistant.

Cavity walls, particularly brickfaced cavity walls, may be made highly resistant to leakage through the wall facing. However, as usually constructed, facings are highly permeable, and the leakage is trapped in the cavity and diverted to the outside of the wall through conveniently located weep holes. This requires that the inner tier of the cavity be protected against the leakage by adequate flashings, and weep holes should be placed at the bottom of the cavities and over all wall openings. The weep holes may be formed by the use of sash-cord head joints or 3/8-inches-eter rubber tubing, withdrawn after the wall is completed.

Flashings should preferably be hot-rolled copper sheet of 10-oz minimum weight. They should be lapped at the ends and sealed either by solder or with bituminous plastic cement. Mortar should not be permitted to drop into the flashings and prevent the weep holes from functioning.

3.2.8 PREVENTION OF CRACKING:

Shrinkage of concrete masonry because of drying and a drop in temperature may result in cracking of a wall and its cementitious facing. Such cracks readily permit leakage of wind-driven rain. The chief factor-reducing incidence of shrinkage cracking is the use of dry block. When laid in the wall, the block should have a low moisture content, preferably one that is in equilibrium with the driest condition to which the wall will be exposed.

The block should also have a low potential shrinkage.
Formation of large shrinkage cracks may be controlled by use of steel reinforcement in the horizontal joints of the masonry and above and below wall openings. Where there may be a considerable seasonal fluctuation in temperature and moisture content of the wall, high-yield-strength, deformed-wire joint reinforcement should be placed in at least 50% of all bed joints in the wall.

Use of control joints faced with calking compound has also been recommended to control shrinkage cracking; however, this practice is marked by frequent failures to keep the joints sealed against leakage of rain. Steel joint reinforcement strengthens a concrete masonry wall, whereas control joints weaken it, and the calking in the joints requires considerable maintenance.

3.2.9 WATER-RESISTANT SURFACE TREATMENTS FOR ABOVE-GRADE WALLS:

Experience has shown that leakage of wind-driven rain through masonry walls, particularly those of brick, ordinarily cannot be stopped by use of an inexpensive surface treatment or coating that will not alter the appearance of the wall. Such protective devices either have a low service life or fail to stop all leakage.

Both organic and cementtitious pigmented coating materials, properly applied as a continuous coating over the exposed face of the wall, do stop leakage. Many of the organic pigmented coatings are vapor barriers and are therefore unsuitable for use on the outside, "cold" face of most buildings. If vapor barriers are used on the cold face of the wall, it is advisable to use a better vapor barrier on the warm face to reduce condensation in the wall and behind the exterior coating.

Coatings for masonry may be divided into four groups, as follows: (1) colorless coating materials; (2) cementitious coatings; (3) pigmented organic coatings; and (4) bituminous coatings.

Colorless coating Materials. The colorless "waterproofing" are often claimed to stop leakage of wind-driven rain through permeable masonry walls. Solutions of oils, paraffin wax, sodium silicate, chlorinated rubber, silicone resins, and salts of fatty acids have been applied to highly permeable test walls.

Of standards under exposure conditions simulating a wind driven rain Most of these solutions contained not more than 10% of solid matter. These treatments reduced the rate of leakage but did not stop all leakage through the walls. The test data show that colorless coating materials applied to permeable walls of brick or concrete masonry may not provide adequate protection against leakage of wind driven rain.

Solution containing oils and waxes tended to seal the pores exposed in the faces of the mortar joints and masonry units, thereby acting more or less as vapor barriers, but did not seal the larger openings, particularly those in the joints.

Silicone water repellent solutions greatly reduced leakage through the walls as long as the treated wall faces remained water repellent. After a exposure period of 2 or 3 hr, the rate of leakage gradually increased as the water repellency of the wall face diminished.

Coating of the water repellent, breather type, such as silicone and soap solutions may be of value reducing aborption of moisture into the wall surface. They may be of special benefit in reducing the soling and disfiguration of stucco facings and light colored masonry surfaces. They may be applied to precast concrete panels to reduce volume changes that may be otherwise result from changes in moisture content o the concrete. However, it should b noted that a water-repellent treatment applied to the surface may cause water, trapped in the masonry, to evaporate beneath the surface instead of at the surface. If the masonry is not efflorescence, application of water-resistant joint. Furthermore, application of a colorless material make the treated face of the masonry water repellent and may prevent the proper bonding of a cementitious coating that could otherwise be used to stop leakage.

Cementitous Coating: Coatings of Portland-cement paints, grouts, and stucco and of pneumatically applied mortars are highly water-resistant. They are preferred above all other types of surface coatings for use as water-resistant base coatings on above grade concrete masonry. They may also be applied to the exposed faces of brick masonry walls that have not been built to e water-resistant.

The cementitious coatings absorb moisture and are of the breather type, permitting passage of water vapor. Addition of water repellents to these coatings does not greatly affect their water resistance but does reduce the soiling of the surface fro the absorption of dirt-laden water. If more than one coating is applied, as in a two-coat paint or stucco facing job, the repellent is preferably added to the finish coat, thus avoiding the difficulty of bonding a cementitious coating to a water repellent surface.

The technique used in applying the cementitious coatings is highly important. The backing should be thoroughly dampened. Paints and grouts should be scrubbed into place with stiff fiber brushes and wetting should properly cure the coatings. Properly applied, the grouts are highly durable; some grout coatings applied to concrete masonry test wall were found to be as water resistance after 10 years of doors exposure when first applied to the walls.

Pigmented Organic Coating: These include textured coatings, mastic coatings, conventional paints, and aqueous dispersion. The thick textured and mastic are usually spray applied but may be applied by trowel. Conventional paints and aqueous dispersions are usually applied by brush or spray. Most of these coatings are vapor barriers but some textured coatings, conversional paints and aqueous

dispersions are breathers. Except for the aqueous dispersions, all the coatings dispersions, all the coatings are recommended for use with a primer.

Applied as a continuous coating without pinholes, the pigmented organic coatings are highly water resistant. They are most effective when applied over a smooth backing. When they are applied with a paintbrush or spray by conventional methods to rough textured walls. It is difficult to level the surface and to obtain a continuous water resistant coating free from holes. A scrubbed cementitious grout used as a base coat or such walls will prevent leakage through the masonry without the use of a pigmented organic coating.

The pigmented organic coatings are highly decorative but may not be as water resistant, economical, or durable as the cementitious coatings.

Bituminous Coating: Bituminous cutbacks, emulsions, and plastic cements are usually vapor barriers and are sometimes applied as " dampproofers" on the inside faces of masonry walls. Plaster is often applied directly over these coatings, the bond of the plaster to the masonry being only of a mechanical nature. Tests show that bituminous coatings applied to the inside of the faces of highly permeable mansard walls, not plastered, will readily blister and permit leakage of water through the coating. It is advisable not to depend on such coatings to prevent the leakage of wind driven rain unless they are incorporated in the masonry or held in place with a rigid self-sustaining backing.

Even though the walls are resistant to wind-driven rain, but are treated on their inner faces with a bituminous coating, water may be condensed on the warm side of the coating and damage to the plaster may result, Whether the walls are furred or not. However, the bituminous coating may be of benefit as a vapor barrier in furred walls, if no condensation occurs on the warm side.

3.3 WATER AND FOUNDATION

Foundation types are a major consideration when building on sites that are on flood plains or sites with high water table. In choosing this, pile foundation will be most suitable.

A pile is defined as structural unit introduced into the ground to transmit loads to lower soil or to later the physical properties of the ground. It is of such shape, size, and length that the supporting material immediately underlying the base of the unit cannot be manually inspected. This definition doe not limit the type of materials making up the pile, the manner of insertion into the ground, or the loads to be transferred to lower strate. However, where manual inspection of the bottom is possible, as in shallow pits or sufficiently wide, deep caissons, these types of construction are not classified as piles.

3.3.1 Timber Piles

Continuously kept wet, timber piles are quite permanent. But a narrow band of alternately wet and dry condition sometimes caused by seasonal water level fluctuations, will soon apparent in pile failures. Where timber piles may be partly above water level, the pile should be pressure treated to a final retention of not less than 12b of creosote per cubic foot of wood. The tops of all creosoted piles as cut off should be below ground level and the cut-off section should be treated with three coats of hot creosote oil. Creosoted piles above ground level require some placement of preservative with age, as well as protection against fire damage. Almost every kind of timber can be used for pile. Some species take the shock of driving better than others, and the species have different static compression values. Prime-grade sticks cannot be expected to be sold for piles; yet it is reasonable to insist on timber cut above the ground swell and free from decay, from unsound or grouped knots, from wind shakes, and short reserved bends. The maximum diameter of any sound knot should be more than 4in the lower half of the pile length or more than 5 in elsewhere. All knots should be trimmed flush with the body of the pile and ends should be squared with the axis.

Piles should have reasonable uniform taper throughout the length and should be so straight that a line joining the centers of point and but should not depart from the body of the pile. All dimensions should be measured inside the bark, which may be left on the pile if untreated but must be removed before treatment with any preservative. The diameter at any section is the average of the maximum and minimum dimensions; piles not exactly circular in section not be rejected. No timber pile should have a point less than 6 in a diameter, except for temporary use. Where the point is reinforced with a steel shoe, the minimum dimensions is at the upper end of such shoe. No untreated timber piles should be used unless the cutoff or top level of the pile is below permanent water-table level. This level must not be assumed

higher than the invert level of any sewer, drain, or subsurface structure, existing or planned, in the immediate vicinity, or higher than the water level at the site resulting from the lowest drawdown of wells or sumps.

Of the various timber species, cedar, western hemlock, Norway pine, or similar kinds are restricted to an average unit compression at any section of 600 psi; cypress, Douglas fir, hickory, oak, southern, pine, or similar kinds are allowed a value of 800 psi. A maximum load of 20 tons is commonly allowed on timber piles with 6 in points, and 25 tons where the point is 8 in or more, subject, of course, to compliance with indicated or tested driving resistance and maximum stress. Timber piles are seldom used as end bearing piles, but there is no real objection to such use , if the piles are properly installed.

3.3.2 Steel H Piles

Where heavy resistance exist in layers that overlie the bearing depths, steel H piles will often take the punishment of the heavy driving much better that any other type. After insertion in the ground, the soil gripped between the web and inside faces of the flanges becomes an integral part of the pile, so that frictional resistance is measured along the surface of the enclosing rectangle and not along the metal surface of the section. To prevent local crippling during driving, the section should have flanged projections not exceeding 14 times the minimum thickness of metal in either web or flanged and with total flange width not less than 85% of the depth of the section. All metal thick nesses should be at least 0.40 in. Other structural steel sections, or combinations of sections, having flanged widths and depths of at least 10 in and metal thickness of metal in either web or flanged – usually in combinations with steel sheeting. Most rolling mills issue special sections for use as piles. The load carrying value of a steel pile is usually restricted to a maximum unit stress of 12,600 psi at any cross value of a steel pile is not more than 35% of the yield stress.

1.3.3 Concrete Piles

Precast piles are most suitable for larger projects. The necessity for accurate length determination and the added cost of cutoff, plus the high cost of equipment to make and handle the piles, tend to make precast piles more expensive than the various cast- in-place types.

Precast piles must be reinforced for local stresses during lifting and driving and must be cured to full strength before use. Prestressing is economical for precast piles, since the cost of ordinary reinforcing is at least half the total cost of a precast pile before driving.

Cast-in-place concrete piles come in many variations, in which concrete fills premolded cavities in the sol. The cavity for a pile can be formed by removal of the soil or by forcing the volume displaced into the adjacent soil, as is done by timber or precast concrete piles. The soil cavity can be made by auger or casing carried to a desired depth and filled with concrete. Volume displacement is accomplished by driving a thin, metal, closed end shell stiffened with a retractable mandrel or a heavier cylindrical metal shell, which is retracted as the concrete filling in installed. Retracted shells are usually heavy steel pipe, sometimes with reinforced cutting edges with driving rings wedded at the top to provide a grip for retraction. In some types, the concrete is compressed by a vibrating or drop hammer and tends to squeeze out laterally below the casing to form annular expansions. These greatly increase the bearing value of the pile. One advantage of cast in place or thin shell piles is the inspector's ability to examine the cavity before replacement of the concrete, to check depth of penetration and variation from plump or desired batter position. Usually, the downward movement during casing driving indicts the empirical resistance taken as a measure of pile value, before any concrete placed.

For all cast-in-place piles, care must be exercised to clean the cavity of all foreign matter and to fill the entire volume with concrete. If water enters shell, tremie tubes may be necessary for casting the concrete. Structural concrete piles are designed as short concrete columns. A maximum unit stress of 25% of the 28 day cylinder in compression is permitted for working-stress design or appropriate load factors, an assumed 5% eccentricity of loading, and o= 0.70 (0.75 where a permanent steel casing of ¼ in or greater wall thickness is used) may be applied for ultimate strength design. Reinforcement steel is evaluated as for reinforced concrete as part of a pile may, with a 1/8 in allowance for loss in thickness by corrosion, be stressed to 35% of the yield stress.

Concrete Displacement:

The Franki extrusion pile requires a steel shell to be set into a pit. The bottom is filled with gravel or dry concrete to a depth of two or three pile diameters, and the fill is then pushed into the soil by dropping a heavy ram inside the shell. The concrete packs and grips the shell sufficiently to pull it along through almost any type of soil and extrudes it into the soil in the shape of an inverted mushroom.

Concrete is added before the plug material entirely clears the shell. As the additional concrete is extruded, the shell is withdrawn.

The result is very rough-surfaced concrete cylinder with a number of annular fins projecting into the soil. At the bottom is a mushroom-shaped expansion. Under load tests, these piles have carried much more load than is indicated by the area of the mushroom multiplied by the normally presumptive bearing capacity of the soil. These piles are suitable for granular soils and develop load capacities of 100 to 150 tons.

CHAPTER FOUR

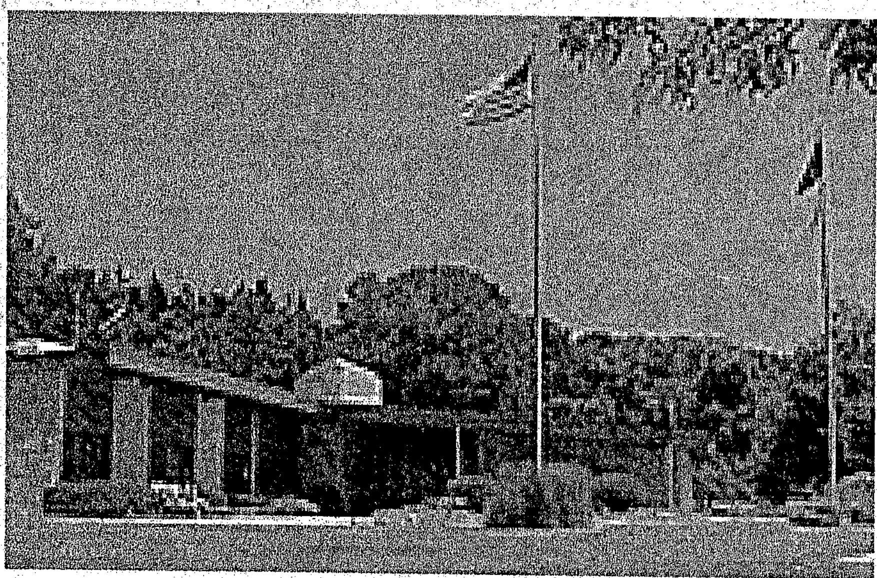
CASE STUDIES

4.1 CASE STUDY ONE

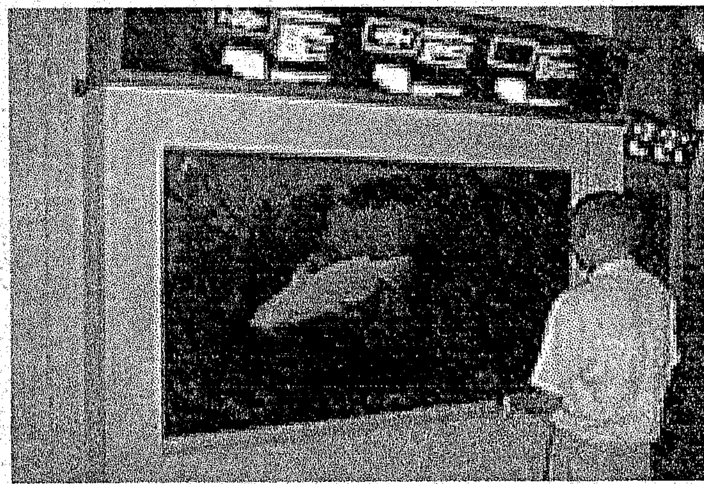
Name: Aksterben Aquarium and Nature Centre

Location: Nebraska, USA

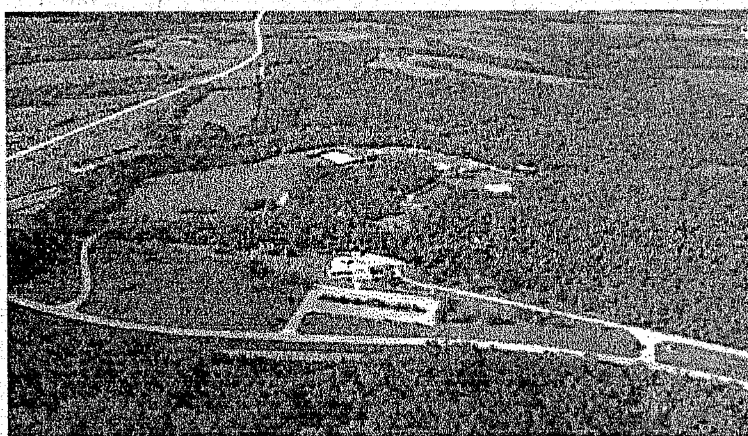
History: This Game and Parks Commission complex is the only facility of its type in the Great Plains. Many organizations and individuals worked long and hard to bring it into reality. Its 12,000 square feet include the aquarium, terrarium, natural history classroom, World Herald Auditorium, orientation and display area, and office



Elevation of Education Centre



Aquarium tank



Arial view of site

Facilities:

- Park
- Wildlife
- Fishing
- Boating
- Hunting
- Outdoor education
- Administration

Materials used:

- steel
- concrete
- glass

- Outdoor forum

Merits:

a the site ha an outstanding layout
b good exhibition of natural wildlife
c material used are durable
d the centre offer educational facilities
e required facilities were well catered for

Demerits:

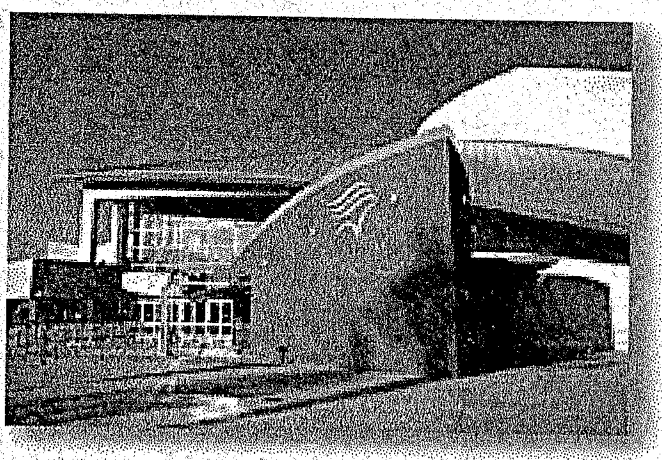
a building are poorly ventilated
b exhibition hall I poorly lighted(use of artificial lighting)

4.2 CASE STUDY TWO

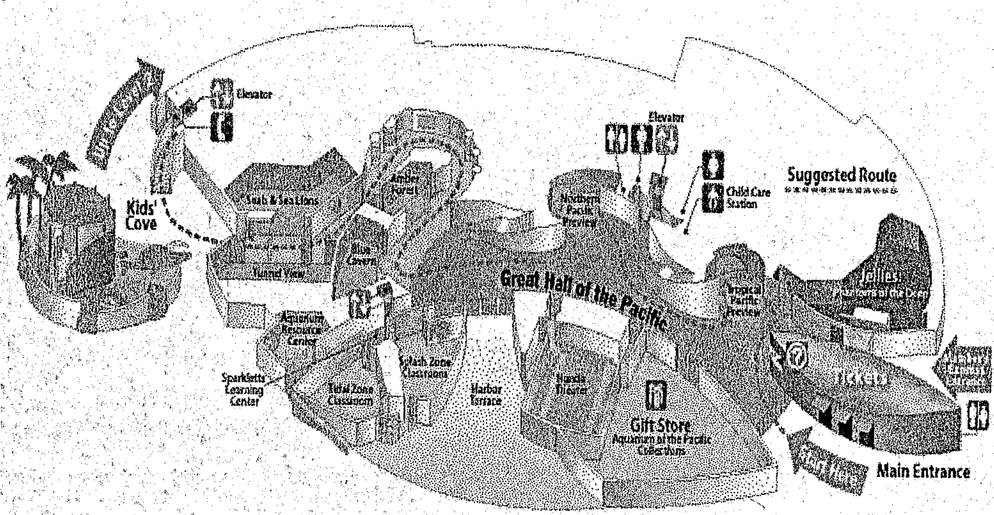
Name: Aquarium of the Pacific Animal Care

Location: Long Beach, California

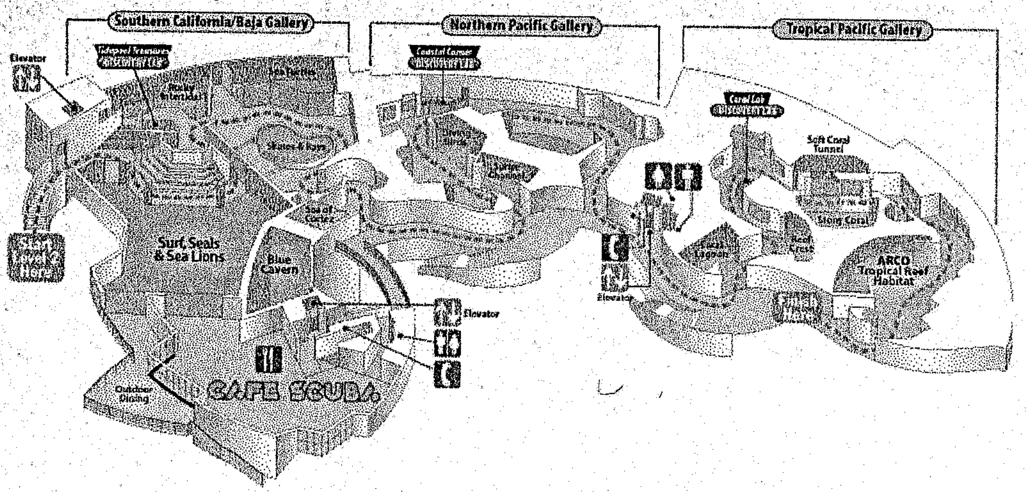
History: With its sweeping, curving, wave-like architecture, the aquarium of the Pacific is designed to emulate the ocean. The Aquarium's extraordinary architecture is a joint venture of the Los Angeles office of Hellmuth, Obata & Kassanbaum and Esherick Homsey Dodge and Davisof San Francisco. EHDD designed the critically acclaimed Monterey Bay Aquarium and has collaborated on the plans for numerous marine exhibitions worldwide. The Aquarium of the Pacific I situated a close to water as the site would allow. There are many outdoor exhibits too, with decks where visitors can see and smell the sea. The design help to remind you exactly where you are, very near the great ocean itself



Approach elevation of exhibition hall



Ground floor plan



First floor plan

Facilities on site:

- conference centre
- research laboratories

Material used:

- glass
- concrete

- northern Pacific gallery
- southern Pacific gallery

- steel

Merits:

a the site is located close to water body
b durable materials were used in construction
c required facilities were well catered for
d aquarium provided house ocean, brackish and fresh water animal

Demerits:

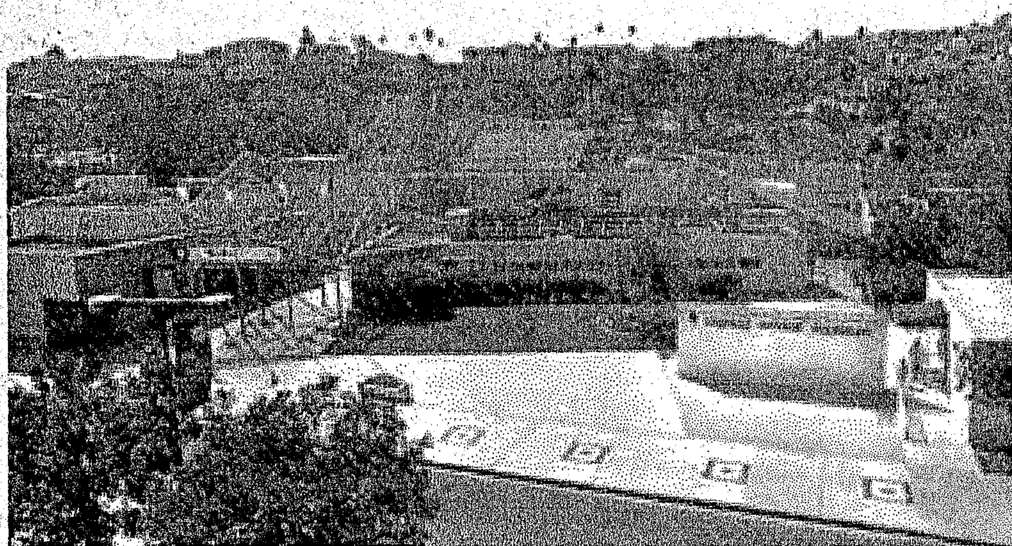
a lots of artificial lighting a used
b lack of good ventilation

4.3 CASE STUDY THREE

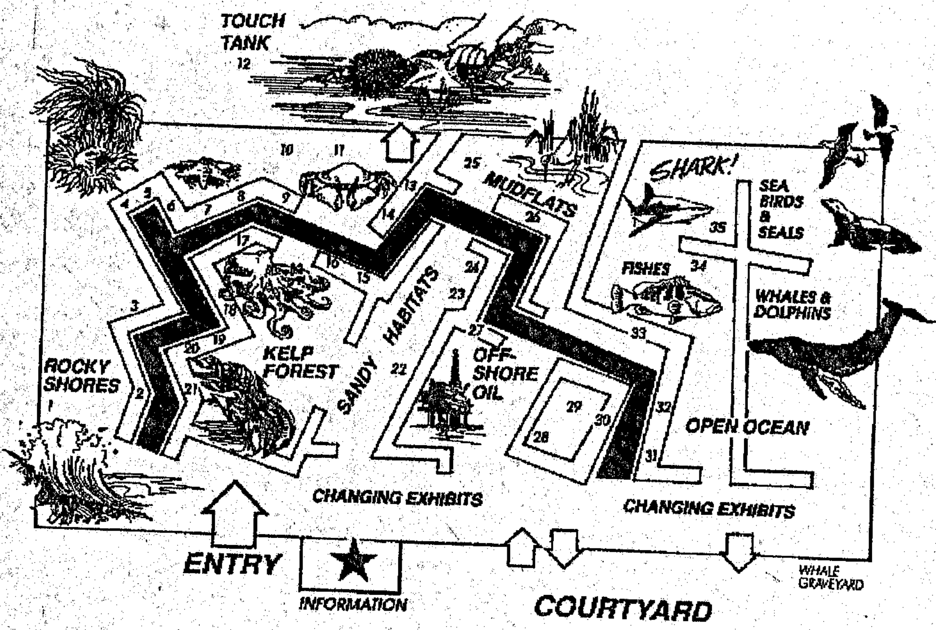
Name: Cabrillo Marine Aquarium

Location: San Pedro, Los angeles

History: Cabrillo Marine Aquarium is dedicated to promoting awareness, knowledge, and preservation of the rich marine life of southern California. Through our many living and interpretive exhibits, sea water laboratories, and surrounding seashore habitats, you will have the opportunity to explore the many wonders of the sea. Located on Cabrillo Beach in San Pedro, our coastal park site includes a gift shop, grassy park and picnic areas, a tidepool refuge, sandy beaches and a fishing pier, all joined by fully accessible trails.



Ariel view of exhibition hall



Site plan of the site

Facilities:

- sea search marine biology
- ocean outreach
- aquarium tours
- whale watch

Materials used:

- glass
- steel
- concrete

Merits:

a the site is well located, having natural features like water bodies around it.
b the buildings have adequate number of facilities
c materials used are very durable
d adequate provisions were made for varieties of marine life

Demerits:

a the buildings are poorly ventilated
b fresh water marine life was well catered for.

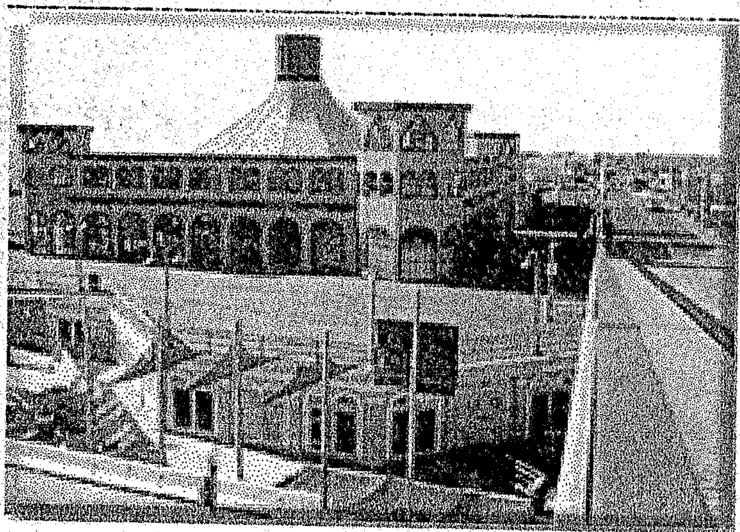
4.4 CASE STUDY FOUR

Name: UCLA Ocean Discovery Centre

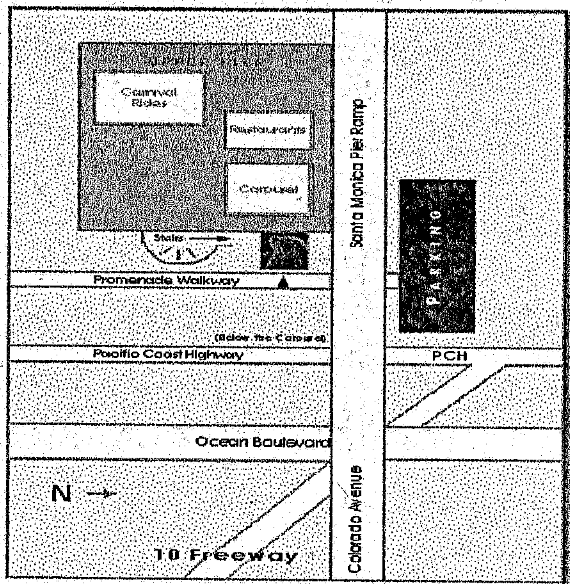
Location: Santa Monica Pier, Colorado.

History: The UCLA Ocean Discovery Center is located at beach level below the world famous carousel on the Santa Monica Pier, where Colorado Avenue in Santa Monica meets the Pacific Ocean.

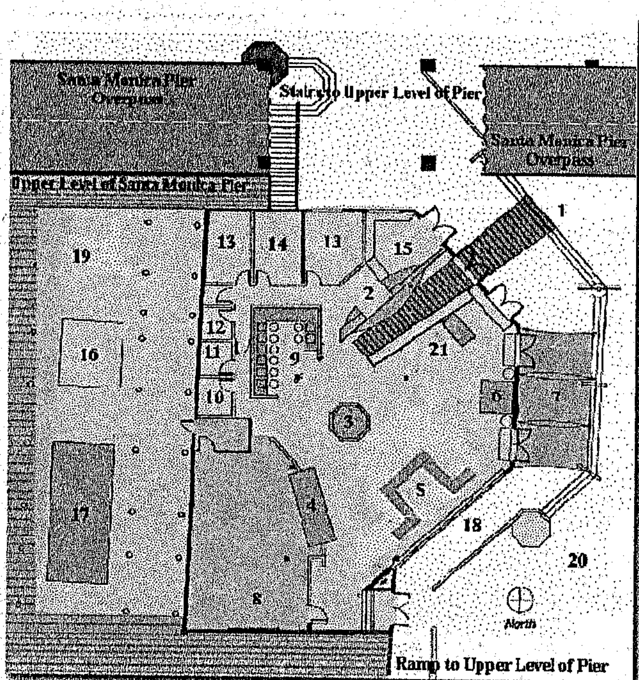
Turn left on Ocean Blvd. at the entrance to the pier. Go south on Ocean past the intersection with Pacific Coast Highway. Turn right onto Seaside Terrace, which is the first small street just past PCH. At the stop sign at the bottom of the hill, turn right onto Appian Way. At next stop sign, turn left and proceed into beach parking lot.



Arial view of elevation



Site location map



Floor plan

Facilities:

Materials used:

Facilities:

1. Entry Gangplank
2. Arrival Counter
3. Schooling Tank
4. Pier Tank
5. Touch Tanks
6. Shark Tank
7. Outdoor Exibit area
8. Classroom
9. Computer/Microscope Laboratory
10. Girls' Restroom
11. Boys' Restroom
12. Staff Restroom
13. Staff Offices
14. Volunteer Lockers & Storage
15. Book Store
16. Storage Shed
17. Water Filtration
18. Student Artwork
19. Storage Area below the pier
20. Promenade
21. Rocky Reefs

Materials used:

- concrete
- glass

Merits:

a it has a good site layout

b the site is well located

c durable materials were used

Demerits:

a Poor ventilation within the building

b poor lighting within the building

DEDUCTIONS

Having carried out these case studies and further analyzing them, several precautions and modifications will be ensured so as to arrive at a proper well planned proposal for this thesis.

Construction materials that will be most appropriate in specifications will have to be majorly steel, glass and concrete. More thought will have to be given to ensuring the use of natural lighting and ventilation by introducing a well-positioned courtyard, increasing the headroom of the exhibition hall and proper positioning of windows. Great detail will have to be given to the positioning of facilities in the buildings.

CHAPTER FIVE

CLIMATE DATA

Since the site for the proposal Naval Base Olokun, Apapa is situated within lagos metropolis, the climate feature of the site can regarded as being the same with that for Lagos state.

5.1 WIND

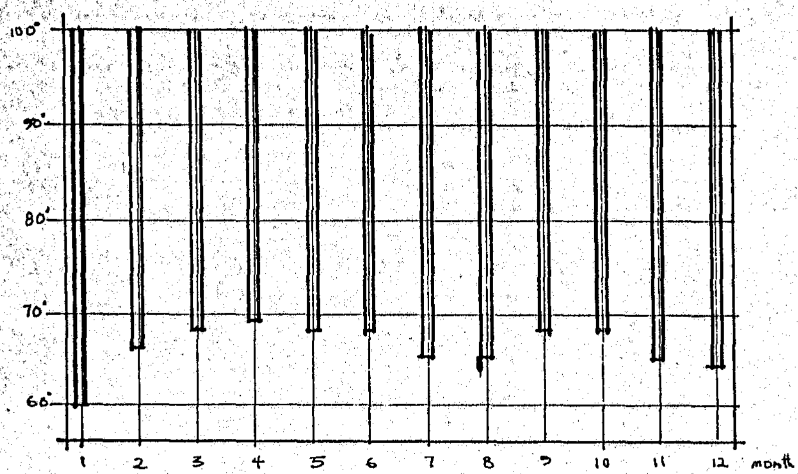
The yearly average of percentage frequency of winds of more than 3 miles per hour (3.4 p. h) the wind speed on the site are of great importance and should and can be controlled if need be, by the planting / existence of suitable trees.

There are two types of winds :The North –East trade winds, which brings harmattan and the South – West mansoon winds, which bring the rains the effect of this winds must be properly curtailed if any tourist facility is to succeed. Peak visiting hours to this site will be mainly at annual public holidays, The fixed ones being in April, October and December –primarily during the rainy season.

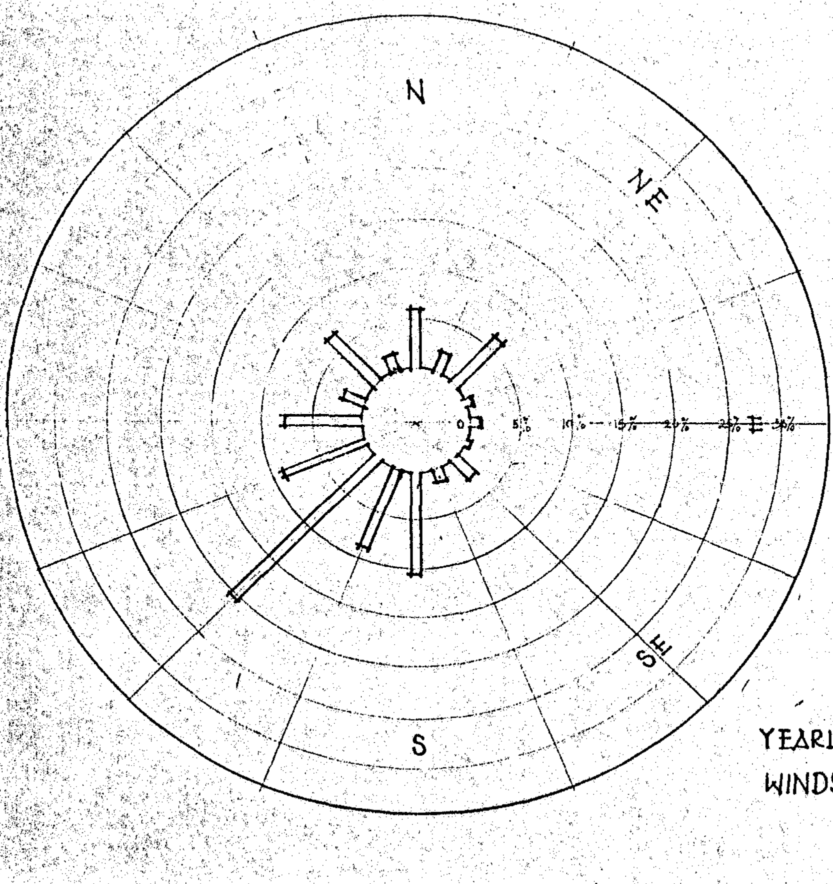
The rain cannot stop, but its harsh effect when accompanied by strong wind can be tempered by barriers and good building orientation.

Surface wind generally correspond to the wind currents which are south west and the south west winds are very moist and when it prevails, brings cloudy sky and rain while the North East in very dry and produces cloudless weather, picking up and carrying fine dust and sand particles on its passage though the desert and therefore produce harmattan.

DATA



ABSOLUTE MONTHLY EXTREMES



YEARLY AVE. OF %TAGE FREQUENCY OF WINDS OF MORE THAN 3 M.P/H

All the climatic factor taken into consideration, if properly utilized in building orientation will only serve to enhance the fact that the site is suitable for the purpose which is presently serving.

% WIND FREQUENCY FOR LAGOS BASED ON 3 HOURLY WIND RECORD FOR 1951 – 60 (LATITUDE 60^0 35^1; LONGTITUDE 03^0 21^1 ATITUDE 40M)

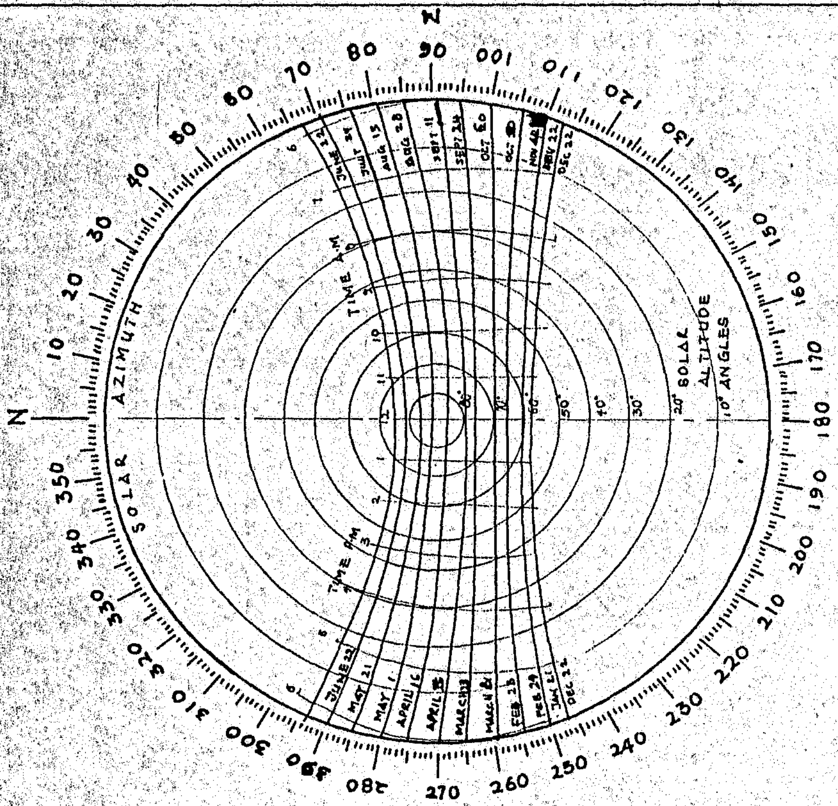
SPEED RANGE IN KNOTS	TOTAL ALL DIRECTION											
	J	F	M	A	M	J	J	A	S	O	N	D
CALM	26.3	21.8	24.1	27.3	26.9	25.3	20.7	20.8	25.6	32.5	31.2	29.0
1-10	73.2	76.7	72.2	69.8	71.3	73.8	76.7	76.4	72.8	66.2	28.1	70.8
11-12	0.5	1.4	3.1	2.7	1.7	0.8	2.6	2.7	1.6	1.1	0.7	0.1
21-23		TR	0.1	0.1	0.1						0.1	TR
34 OR MORE				TR							0.1	

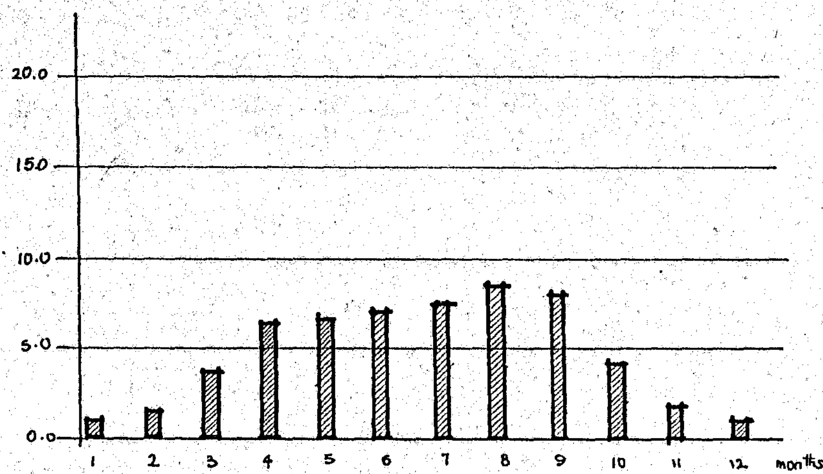
REMARK : 2 OR 3 COUNTED AS 0.1

(SOURCE : FED. MET. SERVICE OSHODI LAGOS)

Rainfall

Rainfall in lagos state in generally heavy as a result of its locations close to the Atlantic ocean and its elevation of about 6m the sea level. The rain falls all years around and is heaviest between April and July. These very rain are usually followed by a short dry season in august and thereafter, another very rainy season between September and October. Generally, lagos state falls into the equatorial zone with annual rainfall measuring up to 1875mm. See attached figure below 62% occurs





MEAN MONTHLY RAINFALL

Isolation And Radiation

Seasonal variations in the length of day in Nigeria is not great. Maximum possible hours of sunshine vary between 12 hours 25minutes and 13 hours 1 minute in June in the south of Nigeria. In January these value range from 11 hours 15 minute in the North and 11 hour 35 minute in the South. The actual total of isolation receive at the earthly surface is substantially reduced mainly by cloudiness whose effect is marked in the South due to proximity of the Atlantic ocean and the persistence influence of humid South - West wind. Thus in coastal area such as Lagos, the early sunshine values lie between 45% and 55% of the maximum.

With particular reference to the site, with a great number of palm trees and surrounding scrubs provide just the right amount of cover to project prospective visitors from a blaring sun.

The solar angle chart shown in fig. 5a is used as a reference point to the site since it was drawn up specially for the different faces of the central and academic buildings (which are very close to the site) showing the sun angles at summer solstice (June 21). Equinox (September and March 21) and white solstice (December 21). They will be used as sun control data for the project.

Bio Climatic Chart

For human physical comfort the chart recommends:

(a) Temperature range of 20^0C to 30^0C

(b) Radiation level lower than $100W/M^2C$

(c) Wind speed (or air movement) less than 0.1m/s

(d) Relative humidity of between 305

For inferences drawn from various data collected, optimization of these data will in no small way assist in the thorough formulation of a comprehensive design proposal.

5.4 GEOLOGY AND TOPOGRAPHY

Geology

Sedimentary rocks of the lower cretaceous period occurs widely in Lagos state. also, tertiary beds from the coastal plain sands stretching from Calabar in far east through Lagos State to the boarders of Benin Republic in the West.

Topography

Lagos State lies entirely within the coastal plan, which is characterized by sand, bank, lagoons and creeks. The land does not rise 650 meters above sea level anywhere in the state. Rather most areas lie below 320 meters above sealevel. In addition, steady coastal retreat is occurring in some areas as a grand scale beach erosion. The rivers, creeks and lagoons in the state fashion. From the west boundary creek enters from the republic of Benin and it is joined in the North, about 24km.From the Nigerian – Benin border, by the Yewa river. Then comes Ologe lagoon looking almost like the Capsian sea in shape. The Lagos lagoon dominates the rest of the state. Drawing into the lagoon are numerous stream and rivers flowing in from the not important ones being the Owo, Ogun, Solode-Barre, Owa and Osun rivers.

The interconnecting pattern of these water bodies creates a large number of islands with varying sizes.

One consequence of the foregoing is the existence, over most of the states, Swamp lands of low to very low agricultural productivity. Only very land of the Northern fringe of the state has soils of good potential for agriculture.

5.5 SOCIO CULTURAL LIFE

The indigenous people of Lagos state are the Yoruba subgroups of the Aworis in Ikeja, the Egus in Badagry area, the Ijebus in Ikorodu and Epe, while Lagos Island consist of an administer of Benin and Eko Aworis as well as repatriated Yorubas and other immigrants. However, the state in its modern form is a socio-cultural meeting point which has attracted a cross-section of Nigerians from all over the federation as well as non-Nigerians from other African countries and the rest of the world.

Nevertheless, Lagos State has its own distinct cultural characteristics, which have been nurtured along by its indigenous people. The arts and craft of the state include pottery, sculpture, mat weaving, basket weaving, hair plaiting and Rafia works. The cultures of the people are also reflected in certain types of masquerades which have particular times of the year for their festivals and some of which originate from ancient religious practices. The major festivals include those of the "Adamu Orisha (Eyo Masqueraders) of Lagos Island / Egunegun, Kori and Osun Iya – Alaro festivals of Ikeja, Eluku festival at Ikorodu, Ebi festival and Okoso festival (Boat Regatta) of Epe, the Sangeto masquerades of the state's cultural heritage.

5.6 ECONOMY

The economy of Lagos State, especially metropolitan Lagos, forms the hub of Nigeria's national economy. This is not suprising in view of the state's traditional role as the Federal Capital of the country until some years ago. Currently, metropolitan Lagos continues to provide, serve as, or support the following:

(a) The most elaborate port facilities in the country;

(b) The older and busier of the two railway termini on the country's Atlantic coast;

(c) The country's busiest international and domestic airports;

(d) The range of buildings and allied infrastructure which the federal administration and its parastatals have used hitherto (and most of which they still use);

(e) The headquarters of most merchant, commercial and the development banks as well as insurance and re-insurance companies;

(f) The Nigeria stock exchange and allied institutions;

(g) The largest concentration of industrial and commercial establishments in the country together with the diversified activities allied to them;

(h) The whole paraphernalia of the Lagos State administration itself and those of its dominantly urban-based local government units;

(i) A wide ranges of educational institutions including polytechnics, college of education, universities and research institutions;

(j) The seat of diplomatic missions to Nigeria;

(k) The location of various international organizations;

(l) A wide range of hotels and recreational facilities;

(m) The terminus of road transportation to various parts of the country and the rest of West Africa;

(n) The largest receptacle of migrants, both rural, urban and internationals

(o) A large and growing population of skilled and semi-skilled persons that provide bases and market for a wide range of higher order goods and services.

These and other functions make Lagos "tick" and provide the state with a bright and magnetic economic climate. Regardless of the change in it's status as the national capital, and given the inertia and circular and cumulative causation processes that characterize economic development, the hegemony and growth of the Lagos area appear well into the future. What policy makers may worry about is how to manage, sustain and further the processes.

5.7 DEMOGRAPHIC DATA OF LAGOS

At the time of the 1963 national census, the population of Lagos was put at 1,443,568. By the end of 1985, 7.3 million inhabitants were estimated using an annual growth rate of 8% in the urban populated areas, and 2.5% per annum in the rural areas with spare population. Lagos State in particular is a constant victim of rural-urban migration in the country and is said to receive 300,000 people per annum or 25,000 people per month. It is estimated that at this rate, the population of Lagos alone may exceed 12 million by the year 2000. A reasonable explanation as per this rapid growth rate in population is directly linked to the industrial potential of the state and the numerous investments being matched both as a source of revenue and per the provision of employment opportunities for the ever-increasing population. In conclusion, the rate of population growth in Lagos State is 10% per annum.

5.8 TRANSPORTATION AND TRAFFIC FLOW

Road Transportation

A city like Lagos with its rapid development leading to increase in population will require a very effective transportation system.

The government's policy concerning the transportation sector is the establishment of a mass transit program, involving the integration of all modes of public transportation. It also involves private sector participation through the provision of tubes, tyres, batteries, lubricants and other major parts for sale at reasonable prices in order to keep transportation fares at affordable prices. To backup this policy, the state government launched a mass transit system consisting of road, rail and water to ease suffering of commuters.

For the road program, more buses were purchased to add to the present fleet of the Lagos State Transport Corporation. In 1991, the corporation had a fleet of 514 buses and 50 Peugeot 504 station wagons for its various services. The state received 158 buses under the federal urban mass transit program and by the end of 1992, the current administration in the state have provided 60 out of the planned 1000 buses under its jubilee line program. A major problem of LSTC is the need to acquire enough spare parts to salvage the over 500 broken down buses in its various depots.

Water Ways

The waterways and lagoons, which abound in the state are being increasingly used. For the riverine areas, water transport by canoes and motorised boats have been natural options for a long time. Ferry service between Apapa and Lagos was pioneered by the Federal Inland Waterways and in 1983, the state government established its own ferry services.

These services use jetties at Apapa, Federal Secretariat, Mainland Hotel, Marina, Maroko Queen's Drive and Tarkwa Bay. With increasing state attention in recent times and the negotiated involvement of the Nigeria Posts Plc., the number of vessels and jetties used for passenger and cargo transport in the state have increased remarkably.

Railways

The Nigerian Railway Corporation runs its normal cargo and passenger services from the Iddo terminus to the northern parts of the country. It also traditionally provided skeletal intra-state commuter services between Iddo and Agege in the metropolitan area. Pending the resuscitation of the metroline project, the state government in conjunction with the Nigeria Railway Corporation launched the jubilee rail service in November 1992 to expand the rail commuter service in the state. This has further boosted the tripartite multi-modal transport system (formally initiated in May 1989), involving better integration of the road, water and railway transport facilities in the state. The jubilee rail service has two trains of 10 coaches, each with a capacity of 1500 passengers operating between Iju / Agbado and Ijora / Apapa.

Air Transport

The biggest and most modern airport in Nigeria is the Murtala Mohammed International Airport which accounts for over 50% of the total air-passenger traffic in Nigeria (averaging 6,220,336 people annually in the 1981 – 87 period). The airport complex at Ikeja has three wings respectively for international, domestic and private airlines. Practically all the major airlines of the world operate air services to Lagos. There are provisions in the State regional plan to construct another airport at Lekki Peninsula for domestic travelers in order to relieve pressure on the Ikeja airport facilities.

Traffic Flow

Traffic congestion has almost always been a serious problem in Lagos State, due to no doubt the industrial activities so prevalent in the area. There have been several proposals to the solution of traffic congestion, varying from the establishment of new routes to the curtailing of car movement from day to day.

5.5.1 TRAFFIC DATA

Table 5.1 Composition of traffic on Broad Street from Tafawa Balewa Square.

TYPES OF VEHICLE	COMPOSITION AS A% TOTAL IN YABA
Private cars	59.74%
Taxis	25.74%
Minibus	10%
Trucks, Tankers	6.05%
Motorcycles	3.93%
Bicycles	1.74%

Peak hours are between 7.00 am. And 8.00 am., 11.00 am. And 12.00 noon and between 4.00 p.m. – 6.00 p.m. (Source: OKAFOR, 1998)

The earliest methods used to ease traffic congestion in Lagos State was the installation of traffic light by the Federal Government and the 'odd and even number scheme' also established by the government of which both schemes did not help much. The most recent attempt at easing traffic congestion in the state has been the recent construction of axial roads, bridges and expressways (which are usually still congested, especially the break periods) e.g. the third axial roads. Third Mainland and Oworonshoki road which form outer ring road and actually facilitate traffic flow in and out, of Lagos Island. The Opebi link road which was completed years ago linking Ikeja with Oregun has greatly eased traffic congestion in Ikeja which is a very densely populated and highly industrialized area of Lagos State.

5.9 EXISTING LAND USE AND FUTURE TRENDS

Lagos State as a whole occupies just 0.4% of the federation but accommodates 5% + 0.8% of the nation's population. The state is presently occupying 358,861 hectares of land, of which 75,555 hectares consist of lagoons and waterways.

The Lagos State land department is responsible for the use of land, both present and future use, land allocation, policies as well as insurance and revocation of right of occupancy. The land use in Lagos State is basically divided into areas for residential development, agricultural and industry that is the good blighted area which lack basic infrastructural facilities like drains, roads, water and electricity. 42 of such blighted areas have been identified and improved e.g. Iponri, Badiya, Orile-Iganmu, Ileje, Bariga.

Projects such as urban renewal scheme, the new towns development authority and the Lekki Peninsula scheme have been established for land development purposes e.g. Design of parks, the establishment of new towns, provision of infrastructural facilities in government estates, site selection and construction.

The Lekki Peninsula scheme is the most recent of all developments established for the provision of adequate space for growth of population and consists of an urban residential development along the Atlantic Coastline (Lekki Beach) and agricultural developments including areas for forest and swamp reserves. Another recent development in Lekki is the Victoria Garden City residential scheme, which is a private investment.

The Lekki Peninsula development scheme is a breakthrough in land development in Nigeria in the area of housing, tourism and the generation of substantial foreign exchange.

CHARPTER 6

SITE ANALYSIS

6.1 CRITERIA FOR SITE SELECTION

Based on the purpose of a marine museum, it is essential to consider various factors before siting it since it is meant to house and exhibit marine life, it is therefore bist to be located beside water body.

Factors That Affect Site Selection

a) Closeness to lagoon front: - the lagoon front which bounds the site to the east makes the site appropriate for the design proposal. The type of water body is " brackish water" which has is own form of marine life and will aid in enhance the proposal in the caring out of research work. It is therefore proposed a water channel shall be made from the lagoon into the site so as to have a "natural" pond on site for the viewing of tourists.

b) University siting: - The site has been proposed by the university to be the property of the marine Biology Department for the carrying out of studies related to its course. This suggests that the site shall be of great advantage to the public and even more, to the department of marine Biology.

Since it is located close to the department of marine Biology in the university. It provides the easy monitoring of the site by the department and expertise suggestions and advancement of the department is also ensured. It gives the lecturers and professors a sense of belonging and purposefulness and awareness to be part of an educative productive and community developing project as this.

It ensures the development of research studies that are carried out on marine life not just locally (between other related professionals and institute in the country) but also internationally due to the involvement of capable professionals in the university community.

c) Location of side in the city: - The site can be said to be centrally located in city since " yaba" where the university is located is in the Lagos mainland metropolis. It can be concluded that accessibility of the site by the public is central a so, uniform opportunity is given to the public.

6.2 SITE LOCATION

The proposed site is located in the University of Lagos Akoka, yaba in Lagos State Southwest of Nigeria. The site so bounded by the Oduduwa road to the North, the lagoon on the East, the university staff-training center to the West and the faculty of science to the South.

6.3 SITE CHARACTERISTIC (INVENTORY)

6.3.1 Soil Condition:

The natural existing soil on the site is claying soil and due to its inability to retain water, it results in a susampy nature of the soil, The site is therefore prone to flooding and water logging.

6.3.2 Vegetation

A great number of trees and grass which characterise parts of gardens exist on site and are presently being managed by the university parks and gardens unit. These are all natural occurring and of various species. They form a natural vegetative cover, which covers a large area of the school.

6.3.3 Topography

Existing site maps, as well as visits to the site show, the topography to be a slopy terrain with the land sloping towards the lagoon.

6.4 ACCESS AND CIRCULATION

A minor road runs along two perpendicular sides of the site (the Oduduwa road) which leads to VC's quarter. Room has been made for a proposed road, which is to disconnect from the oduduwa road and run in front of the site from the university gate. This road will ensure easy circulation around the site casing cojestion and traffic jams.

6.5 UTILITIES

Presently, no telecommunication poles, water pipes or electricity poles run across or beneath the site that makes construction works easy to be carried out on site.

6.6 SCENERY / MAN-MADE FEATURES

To the East of the site is scenery (lagoon) which marks one of thew site's boundries and no form of man made features exist on site.

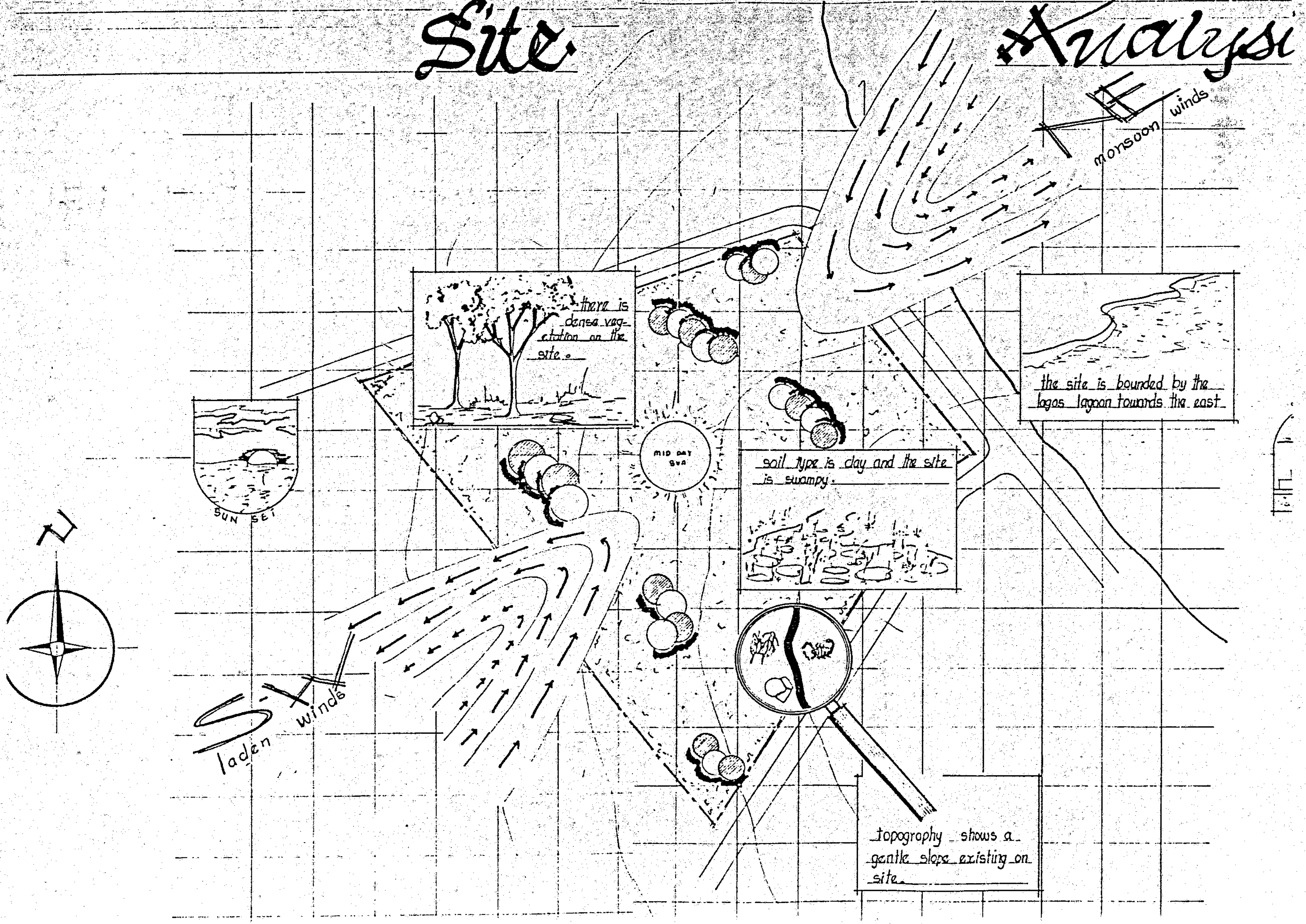
6.7 POLLUTION

Noise pollution seems to be the only form of pollution that to occur on and around the site.

DEDUCTION

After putting all this into consideration, the world in need for excaration if the present soil on site the filling with sandy soil which will be compacted, the existing vegetation will be maintained as much as possible but those that would hinder construction will be cleared and which can be replaced will be. The lagoon life will be channeled into the site to great a brackish water pond which will form part of the exhibition area on site. The yet proves to be conducive due to access and circulation around the area and the topography of the site shall be maintained as much as possible.

Site Analysi



CHAPTER SEVEN

DESIGN CONCEPT AND CONSTRUCTION

7.1 CONCEPT AND DESIGN

Concept: In achieving the final suitable design proposal for the marine museum which would express the type of purpose of the building in plan and elevation, yet fulfill all necessary requirements and function of the design proposal at the same time bringing harmony between the building proposal and the site, thereby achieving the goal of architecture, the analogical concept of a "fish" has been selected.

The Fish: This is a shape directly related to the aqua life and could be said to be a symbol of marine life. Since the museum is meant to display all types of marine life ranging from the fresh water life to the brackish water life and the sea life, there would be a need for flexibility in the proposed plan and elevation. The flexibility should be expressed in the plan by creating informal viewing angles of the aquarium by using irregular shapes of symmetry there by breaking monotony in viewing. This would enhance more exciting views to tourists and sight- seers. The combination of the curve and almost straight angles expressed in the shape of the natural fish is deemed to be able to enhance this criterion. The achievement of this shape in elevation gives a tourist impression of the building there by creating a harmony between the tourist and the purpose of their visitation.

The Egg: This could be said to be the container of a generation, which means it, is an envelope in which life is kept. With this in mind, it is used in the analogical concept of the library and archives of the museum. Since the library and archives are sources of information long gotten which are then kept for the use or production of other discoveries and information, it is well expressed in the shape of the egg

7.2 MATERIALS AND CONSTRUCTION

In the listing and classification of the materials used in the project, the two units involved are treated separately.

1) The aquarium hall
2) The information hall

7.2.1 The aquarium hall

Material used here include

Wall: -Reinforced concrete block
- Sand screed hollow blockwork
- Ceramic wall tiles
- Glass

FLOOR: - Reinforced concrete floor slab
- Ceramic floor tiles
- Cellular steel and concrete floor
- Granolittic floor finish

ROOF: - Membrane structure

- PVC membrane roof covering

- Space frame

- Glass

: - Concrete roof gutter

7.2.2 The information hall

WALL: - Pre – fabricated steel portal frame

: - PVC membrane

: - Sandscreed hollow block

: - Glass

FLOOR: - Reinforced concrete blockwork

: - Granolittic floor finish

: - Cellular steel and concrete floor

ROOF: - PVC membrane roof covering

: - Glass

: - Zeiss- Dywidag dome

: - Concrete roof gutter

Aquarium hall

Floor and Walls:

Knowing that underground floor, are formed in the less compacts soils with poor bearing capacity. These soils are permeable and stain ground water which impose pressure on both the walls and floors underground water. This after low sailable calculations. By reinforcing the easing and allowing for its composite effect with the steel frame, a saving in steel and a reduction in the overall size of the members can be effected.

Underground floors are generally formed in the less compact soils with poor bearing capacity. These soils are permeable and retain ground water, which imposes pressure on both the walls and the floor underground. This, often considerable pressure of water readily penetrates bricks and mortar and the unavoidable shrinkage and construction pressure of water readily penetrates bricks and mortar and the unavoidable shrinkage and construction cracks in concrete. To exclude ground water from building it is necessary to form an unbroken, impermeable membrane in all external walls and floors underground or to render construction joints in concrete watertight.

Basement Tanking:

The traditional waterproof membrane to floors and walls subject to ground water pressure is a lining of asphalt, applied bot in three layers, either to the outside or the inside of walls and sandwiched in the basement floor slab. It is practice to line the outside of walls of brick or concrete, in new building work, with asphalt so that the ground water pressure against the outside face of the asphalt to walls is by the wall inside. An internal lining of asphalt to walls is wall and it is necessary to form an additional internal loading wall to resist this water pressure, and maintain the asphalt in position. This obviously adds to the overall thickness and cost of the basement wall. An internal lining of asphalt is used, in the main, in existing buildings and in new buildings where the necessary 600 of working space outside the walls cannot be provided for the asphaltters to work in.

The horizontal lining of asphalt is laid in three coats to a finished thickness of 30 on the basement floor slab. Joints between each laying of asphalt in each coat should be staggered at least 150 with joints in succeeding costs. The horizontal asphalt is carried out 150 beyond the line of vertical asphalt to allow for forming the reinforcing angle fillet at the junction of the horizontal and vertical asphalt linings. Immediately the horizontal asphalt has been completed it should be covered with a 50 protective coat of cement screed to protect it from damage during subsequent building operations until the concrete loading coat is in place.

A concrete loading coat is spread, consolidated and leveled on the 50 protective coat. The thickness of this loading coat is determined by the ground water pressure it has to resist in order sandwiching the asphalt in the basement slab. It is good practice to reinforce the loading coat and to building brick walls off it. The reinforced loading coat then tends to spread the load of the brick wall and so avoid the possibility of relative settlement, which might cause the asphalt to crack and let in water.

The vertical asphalt lining is applied in three coats to a finished thickness of 20 with joints staggered as previously described. The surface to which the vertical asphalt is applied must be sufficiently rough to provide a key for the asphalt to bond to, by raking out joints between smooth faced bricks and by roughening the surface of concrete cast against smooth forms. A reinforcing two-coat asphalt angle fillet is formed in the junction of the vertical and horizontal linings. The vertical asphalt lining should be taken up 150 above the natural surface of the ground or above paved areas.

Vertical asphalt linings outside the main structural walls should be protected by a half brick thick skin built up against the asphalt. The purpose of this protective skin is to protect the asphalt from damage during subsequent building operations and during the course of backfilling basement excavations around basement walls.

Where an internal asphalt lining is used, the inner loading wall should be built a soon as possible, to reinforce the asphalt against ground water pressure. The inner loading wall is usually of brickwork sufficiently thick to resist water pressure. The loading wall is built with a 25 cavity between it and the asphalt and this cavity is solidly grouted with mortar grout filling is to ensure uniform contact with the asphalt to resist water pressure. Without the cavity and mortal filling there might be cavities between the brick wall and the asphalt and water pressure would force the asphalt into the cavities and so cause it to crack and let in water.

Where column or pier bases are to be cast in with the basement floor slab to bear directly on the subsoil or on a pile cap, it is necessary to continue the horizontal asphalt around the sides and base of the bases to form a continuous waterproof membrane. The excavations for the bases are first lined with concrete, usually 100 thick, or the base is lined with concrete and the sides with half brick thick skins. Asphalt is then spread around the lining and the column or pier bases are cast within the asphalt lining. Where there is appreciable ground water pressure it is not satisfactory to allow columns or piers to penetrate the horizontal asphalt lining to a foundation at a lower level, as water will find its way through the cracks between the columns or piers and the asphalt.

Where service pipes or ducts penetrate basement walls it is necessary to form a watertight joint. The pipe is cleaned and painted with bitumen and an asphalt collar is formed around it. The pipe is then passed through a hole in the reinforcing fillet is formed around the pipe. The wall is then made up around the pipe. Where there is high ground water pressure a flanged pipe connection is used with a lead sheet collar fixed between the flanged pipe wands, which are connected with bolts. The lead collar is then sandwiched between coats of the vertical asphalt lining.

For asphalt lining to effectively resist the penetration of ground water it must be securely sandwiched between floor slabs and loading coats and walls and protective or inner loading walls. When firmly sandwiched in floors asphalt acts as a viscous plastic capable of sustaining considerable loads of the order of $1.0MN/m^2$ without appreciable displacement and capable of taking up slight relative movements without fracture. Any appreciable relative movement will inevitably cause a fracture in the lining through which water will penetrate.

American practice is to line basements, subject to ground water pressure, with coats of bitumen reinforced with sheets of fabric such as canvas or felt, bonded between layers of bitumen. The fabric reinforces the bitumen and gives the lining sufficient resilience to accommodate slight relative settlement and structural movement without damaging the lining. A comparable system employed in this country consists of coats of bitumen reinforced with fabric and bitumised crepe paper.

Concrete Basement Walls and Floors: Thoroughly consolidated dense concrete is impermeable to all but high water pressures. The density and therefore the impermeability of concrete can be improved by the use of integral waterproofing additives, which have the effect of filling the small pores in concrete. These integral waterproofing and hardening additives are added to the concrete mix in the form of fine powders or liquids as the materials are mixed.

As concrete dries out after placing it shrinks and this inevitable4 drying shrinkage causes cracks particularly at construction joints, through which ground water will penetrate. Where there is appreciable ground water pressure on the floor and walls of a concrete structure it is necessary either to line with asphalt as previously described, to take precautions to minimise rubber or plastic water stops.

One method of minimising shrinkage cracks is to cast adjacent bays or areas of concrete in floors and walls with a gap of 450 or 600 between them. When the bays have dried out for some days and most of the drying shrinkage in them has taken place, concrete is then cast into the spaces between the bays. Because of its narrow width this second placing of concrete will suffer only small drying shrinkage and cause only small shrinkage cracking. This method of constructing concrete floors and walls will, without an impermeable lining, provide a reasonably watertight structure in soils in which ground water pressure is low. Where there is appreciable water pressure it is necessary to use an asphalt lining or to cast in rubber or P. V. C. water stops into all construction joints in floors and into vertical construction joints in walls. The water stops have a dumbbell section and are cast into joints. At junctions the strips are mitred and welded together to make a watertight joint. To maintain correct alignment between adjacent bays of the concrete floor it is usual to form a joggle joint.

Horizontal construction joints at lifts in concrete wall are not generally sealed with a water stop as the weight of the concrete wall above the joint is sufficient to provide a watertight joint by compression. Some few hours after a lift of concrete wall has been cast, its top edge is sprayed with water to expose the aggregate to a depth of about 6 to provide a strong mechanical bond for the concrete subsequently cast on to it. These horizontal joints may also be formed as a joggle joint as an added barrier to the entry of water.

7.2 FOUNDATION

Square section form of driven cast-in-place reinforced concrete pile were purposed for the foundations. The base of a steel lining tube, supported on a piling rig, is filled with ballast. A drop hammer rams the ballast and the tube into the ground and at the required depth the tube is restrained and the ballast is hammered in to form an enlarged toe as shown. Hammering it inside the lining tube, which is gradually withdrawn, places concrete. The effect of driving the tube and the ground is to compact the soil around the pile and the subsequent hammering of the concrete consolidates it into pockets and weak strata. The enlarged toe provides

Membrane roof

Membrane Stresses

Although a membrane is a two-dimensional resisting structure, it does not develop appreciable plate stresses (bending and shear) because its depth is very small in comparison with it span. Therefore, the load-carrying capacity of membranes must come from other types of stresses.

A cable can support loads in tension because it sags, and that it is structurally efficient because its tensile stresses are distributed uniformly across its sections. A membrane supports loads by a similar mechanism and presents the same kind of structural efficiency. An element cut out of curved membrane and acted upon by a normal load. Since the sag of the element produces in the membrane curvatures in two directions, the membrane may be considered, at first, as the intersection of two cables; each cable carries a share of the load, and the total load carried by the membrane is the sum of the two "cable" loads. Thus, a membrane is seen to be capable of "cable action in two directions."

The two-dimensional resisting character of a membrane makes it also capable of a second load-carrying mechanism through the development of shears acting within the membrane surface, provided the membrane is not buckled by the equivalent diagonal compression. One may prove that a thin piece of material can develop such shears by holding a vertical sheet of paper along one of its edges and by pulling vertically sheet of paper along its possible edges. The paper sheet carries the load acting in its own plane by tangential shear. But, just as the tension in a horizontal cable cannot carry vertical loads, the shears in the plane of the paper sheet cannot, by themselves, carry loads perpendicular to it. The load-carrying action of a membrane is due to its curved shapes.

In rectangular element cut out of a curved membrane, and indicates that, in general, its four sides are not parallel, but askew in space; this means that one of its sides slopes more than the opposite side, and that a difference in slope occurs between these two sides. The figure also shows that a difference in slope between two opposite sides necessarily requires a difference in slope between the other two opposite sides. The difference in slope between opposite sides is called the twist of the membrane surface. Since the slope of a membrane surface in given direction usually changes from point to point, membranes, in general, have both curvatures and twist. The curvatures and the twist characterize the geometrical behavior of the membrane surface at a given point.

The two pairs of shears on the side of any membrane element have directions that guarantee equilibrium in rotation but in a twisted membrane the difference in slope between two opposite shears produces an excess of normal upward forces It is this may have twist in certain directions and no twist in others. The only surface without twist in any direction is the sphere, since an element cut by any two pairs of parallel sides is identical to an element cut by any other two pairs of sides.

The properties exhibited by the cylinder in relation to curvature and twists are not peculiar to this surface, but completely general. Any surface cut by planes passing through its normal at a point exhibits two directions at right
Angles to each other for which the curvature becomes, respectively, maximum and minimum; for these two perpendicular directions the surface has no twist. It is often convenient to spot principal directions by the lack of twist – that is, of slope change-in these directions.

One may mark by means of small crosses the directions of principal curvature on a membrane surface, as was done for the case of principal stresses, and obtain a pattern of lines of principal curvature. For a cylinder this pattern is a rectangular mesh with sides parallel to the axis and at right angles to it.

The membrane stresses at a point of a membrane have different values in different directions.
Hence, as the orientation of the stress rotate around a point, the stress becomes maximum and minimum in two directions at right angles, the directions of principal stress.
Elements oriented in these directions do not develop shear; shear becomes greatest at 45 degrees to the directions of principal stress.

The directions of principal stress are those in which the membrane acts, as two sets of cables are right angles; one set develops the maximum stress, the other set the minimum stress at each point. Indicating by small crosses the directions of principal stress at a number of points, one may obtain a pattern of principal stress lines for the membrane. Whereas the lines of principal curvature are a geometrical characteristic of the membrane surface, the lines of principal stress depend on the shape of the surface, the character of the load, and the conditions of support. In certain cases of symmetry, the two patterns may exceptionally coincide, as for a sphere or a cylinder under internal pressure.

The analysis of cable action showed that the stresses developed in a cable are inversely proportional to its span-to-sag ratio. Conversely, for a given allowable stress, the greater the sag, the greater the load the cable can safely carry. Considering the cable action of a membrane along its principal stress directions, it is thus found that the direction with greater sag ratio-that is, greater curvature-carries more load than the direction with smaller sag ratio (smaller curvature). In the case of sphere, the curvature is the same in all directions and a spherical membrane under uniform pressure carries half of it by cable action in one direction and half of it by cable action in the other. In case of a cylinder under uniform normal pressure, the straight lines carry no load, since they have no curvature, and the entire load is carried by stresses along the curvature lines at the right angles to the cylinder axis. The stresses developed by this cable action are hoop stresses.

Since buckling stresses are proportional to the square of the thickness-to-span ratio, membranes buckle under extremely low compressive stresses. It is thus correct to say that, to all practical purpose, membranes cannot develop compressive stresses. By the same token, the membranes shears developed by a membrane are also negligible, because shears produce an equivalent 45-degree compression.

Since actual membranes cannot develop compression or shear, they carry load by tension only, and act essentially as a network of cables. When the load changes, the shape of the membrane also changes and adapts the curvatures to the values needed to carry the new load. Membranes, like cables, are unstable; they must be stabilized by the action of an inner skeleton, by the tension produced by external forces, or by internal pressure. Prestressing by tensioning allows the membrane to develop compressive stresses up to values capable of canceling the tensile stresses locked in the membrane; it adds to the advantage of aerodynamic stability that of carrying loads by the shear mechanism.

It must be noted that the stresses in a membrane, being almost totally tensile, are uniformly distributed across its thickness; the utilization of the material in membranes is optimal. Moreover, tensile strains are always small compared to bending strains, so that the membrane deflections due to loads are usually small. (These deflections should not be confused with the displacements of the membrane due to variations in the load, which may be quite large.)

Thus, by the nature of their load-carrying action membranes are light, economical, and stiff under steady loads. As noted above, their use in permanent structures has been limited exclusively by their mobility

Information hall

Floors and Walls: Same as that of the aquarium hall

Dome Roof:

Bending stresses in domes

A dome was shown to carry loads essentially by membrane stresses (compression, tension and shear), because the development of shears makes it funicular for all loads. On the other hand, because it is so thin, if there were anywhere in the dome a tendency to develop bending stresses, these could easily exceed allowable values. It is therefore necessary to investigate the possibility of such a tendency.

In the analysis of the carrying capacity of thin dome it was tacitly assumed that domes are free to develop the minute displacements required by their membrane state of stress. Membrane stresses develop under load, and the corresponding strains give its top a small vertical displacement. Since this deflection is not prevented, a pure state of membrane stress excites in its neighborhood. An entirely different situation may develop, instead, at the boundary of the shell.

A spherical dome with a high rise tends to open up to the equator; its boundary displaces outward, even though by very small amount. Moreover, the reactions supporting the dome are vertical, that is, in the direction of the meridians, since the meridians arches are funiculars of the load; reactions in any other direction would produce bending moments in the dome. In other to have a pure state of membrane stress in the shell, the boundary must be to move outwards, and the reactions must always act in the direction of the meridians. In practical this is impossible. A moving boundary would present practical difficulties and disadvantages; the reactions should rotate in other to remain tangent to the meridians if and when the boundary rotates because of the deformation of the shell under load. In common practice, instead, the equator of the shell is reinforced by a stiff ring, which prevents almost entirely, the outward motion of the boundary and its rotation, and introduces an inwards thrust and bending at the equator. The shell, which would open up at the equator under the membrane stresses induced by the load, develops a kink or sudden change in curvature and, hence, bending stresses around the boundary.

The bending disturbance thus introduced at the boundary does not penetrate deeply into the shell, but is limited to a narrow band in the neighborhood of the boundary. This "damping out" of boundary disturbance, another useful characteristic of thin shells, occurs because the bending displacement of the meridians, which could be large in view of the small bending rigidity of the shell are restrained by the parallels, and, hence, large tensile or compressive strain in the parallel. The parallel instead are stiff in tension and compression and do not allow such large displacements; they permit a small amount of bulging in and out of the meridian and hence a small amount of bending, which peter out as one moves away from the shell boundary. The width of the area affected by the bending boundary disturbance is proportional to the square root of the ratio of thickness to radius of the dome; in order to reduce the width of the disturbed zone the shell must be made thinner. For a thickness equal to one four- hundredth of the radius, the width of the disturbed zone is only one tenth of the radius. Thus most of the shell is actually in a state of disturbed membrane stress.

Bending disturbance, often more severe than those due to the loads, are produced by thermal conditions. When exposure to sun increases the shell temperature, the entire dome changes shape, uniformly increasing its radius. If a ring prevents this boundary displacement, the shell once again presents a sudden change in curvature, and develops high bending stresses of the same nature as those discussed above. Since boundary displacements due to thermal changes are usually larger than those due to the loads, the bending stress due to the thermal expansion are usually larger than those due to the loads, if the temperature of the dome spanning100 feet increases uniformly by 30 degrees Fahrenheit, the dome boundary displaces radially by one tenth of an inch. This displacement is three times larger than that produced by the dead load and a heavy snow load; hence the thermal bending stresses at the boundary are three times as large as those due to the loads.

Whenever the boundary reactions are not tangent to the meridians, bending stresses occur in the neighborhood of the boundary. Thus, if a dome is supported on evenly spaced columns rather than all round its boundary, the membrane stress pattern changes, but more over the columns introduce horizontal reactions at the dome boundary, and bending stress are developed by the dome. Similarly, if portions of the dome are cut out by vertical or incline planes and the dome rest on few points, the support conditions differ substantially from those ideally required by membrane actions, and bending stresses are to be expected. Moreover any load capable of producing a kink of sudden change of curvature in a thin shell is bound to produce bending stresses: thus concentrated loads cannot be carried by membrane stress. The thickness of the shell is often dictated by bending disturbances rather than by the membrane stresses due to the loads.

Two traditional conditions may call for a thickening of shells above the modest requirements of membrane stresses. One concerns reinforced–concrete shells and is of a purely practical character: enough thickness must be provided to cover the reinforcing bars on both the outside and the inside of the shell. The Exact location of the bars in the shell thickness is a delicate and expensive matter; in countries with high labor cost it is often found less expensive to increase the shell thickness than to locate the steel carefully.

Shells must often be thickened to prevent buckling. Any thin structural element subjected to compressive stresses may buckle, and thin shells are no exception. The buckling load for a thin-shell dome is proportional to the modulus of elasticity of the material and to the square of the thickness to radius ratio. With ratio often as small as 1/300 1/400, the buckling load will be exceptionally low. The buckling load for a dome 3 inches thick, spanning 100 feet, is about 150 pounds per square foot; with a factor of safety of 2 1/2, the maximum load on the shell cannot exceed 60 pounds per square foot. This is equivalent to the dead load of the shell, including the roofing or insulating materials, and does not allow for any snow load.

The buckling resistance of a dome may be substantially increased, without increasing its thickness uniformly, by meridional parallel ribs. This practice is well suited to the stiffening of steel domes, in which the thickness required by the membrane stresses may quite small in view of the tensile and compressive strength of the material. Concrete domes are seldom stiffened by ribs because of the cost of forms; the same result is achieved, sometimes, by undulations, which increases the cost of forms, but may also add to the appearance of the shell.

A shell acts "properly" if it develops membrane stresses almost everywhere; it is then said to carry loads by shell action. It was shown above that the following three conditions must be satisfied for a dome to develop thin-shell action.

(1) The dome must be thin; it will thus be incapable pf developing substantial bending action.

(2) It must be properly curved; it will thus be strong and stiff because of its form resistance.

(3) It must be properly supported; it will thus develop a small amount of bending in a limited portion of the shell.

These three conditions are essential to thin-shell action whatever the shape of the shell and the loads on it.

The Zeiss Dywidag Dome a space frame dome which is exceptionally light therefore permits spanning of large distance with relative deduction in materials though it entails delicate connection between bars and involves high cost

CHAPTER EIGHT

DESIGN SERVICES

8.1 ELECTRICITY / LIGHTING

Electricity

Principally, the Nigeria electric power Authority (NEPA) is expected to supple the electricity but the university authority has a stand by generator, which is used at times of power failure. However, since the marine museum is so dependent on water supple through power operated pumps / filters, a stand by generator is proposed as a supplement.

Other proposals for electric supple include: -

- Fluorescent lighting of the appropriate size in all aquarium tanks, galleries and service areas.
- Lighting along all work ways (covered and uncovered).
- Security lights in car parts garden and ponds.
- Fire alarms in the galleries, administrative and restaurant.
- Telephone / intercom systems.

All electrical appliances and equipment including connectors must be grounded outlets should not be located near. The fixture over the tanks (light – up screen) should be selected to avoid breakage. All tank-cleaning devices which fire poles attach to them should be of wood or other non- metalic material. For the fountains and ponds, a residual current circuit breaker will be fitted in the electrical as well as outer cable buried in plastic pipes wat3er proved function boxes switches.

Lighting

Every structural facility on site is naturally lighted and where necessary there shall be provision for additional illumination through artificial lighting using fluorescent tubes lighting system

8.2 HEATING, COOLING AND VENTILATION

The major medium for ventilation I the ue of the courtyard. Units will be required in all galleries as a means of cooling. Split unit will be employed, suspended on walls at strategic points. The condenser units will be placed outside the building

8.3 WATER SUPPLY

WATER SYSTEM

The entire water system in a marine museum comprises:-

1) The in- coming line.
2) A sterilizing unit (optional).
3) Storage reservoirs.
4) The pipelines into types/temperatures of water serving the display tanks.
5) The inflow and outflow drainage.
6) The filters.

There are 2 types of water systems to be chosen from:-

a) **OPEN SYSTEM**

In which the water is used only once and then discarded and is usually used when the aquarium is built near deportable source of water of sufficient quantity and quality.

b) **CLOSED SYSTEM**

In which the water is recirculated and used over and over again. For the purpose of this project, the open system will use since the University of Lagos has a dependable source of water with the borehole project, which has a capacity of one million litres.

i) One type of the closed system is the recirculating total system where water contrivously enter the display tank sand the overflow returns to the resevours after passing through filters. A noted disadvantage of the closed system is the possibility of disease organisms from one tank being carried to all the tanks. Organisms cannot be remove by filtration, ultraviolet radiation or passage through a reserve osmosis process will.

ii) Another type of closed system is one in which each display tank is provided with is own recirculating system. The main supple lines are used for filling and minor water replacements. The overflow from the tanks passes through the a biological filter and is pumped back to the display tanks. The main supple lines are also continually circulating at a flow to preclude dead water and the growth of organism in the pipes.

However, provision will be made for a closed system.

The open is the least complicated provided on adequate source of disease – free water is available.

Tanks (aquarium)

These are the containers in which the specimen are displayed and may vary in size and shape. The most ideal type tank are made of inert material, light in weight, readily altered or drilled inert in sea water and with hard and smooth materials, fiber glass is a satisfactory material or plastic impregnated plywood. Larger tanks may also be reinforced concrete or steel plate.

The tanks will be placed on platforms near the work area to permit cleaning the aquarists. Holding tanks will be used to receive new specimen and will have its own recirculating system. Aquarium tanks will hold sick specimen and will have individual drain valves to permit rapid drainage after treatment procedures.

8.3.1 PLUMBING

The main supple pipe will be extend around the aquarium over the display tanks and will have frequent tap valves from which, by flexible hose, replacement water or a continuous flow may be fed to tanks, depending on the system being used.

Shut- off valves will be conveniently located along the major supple line to facilitate plumping repairs. The possibility of accidental flooding will be reducing by built in overflow drains in the work areas.

Generally, the average display tank of specimen loaded at the rate of 11b of fish per 100 gallons of water should have a turnover or replacement rate of one volume each to 2 hours.

If the gallonage of all display tanks is 100,000 gallons, a flow of 50, 000 to 100,000 gallons per hour will have to be maintained thus 1.2 to 2.4 million gallons will be required each 24 hours.

8.3.2 WATER QUALITY

This aspect is extremely vital to the health of fish and other aquatic specimen since they will likely absorb the water and any disease it may contain through the gills. In order to avoid sudden death of specimen, one safe rule is to ensure that all aquarium and other parts of the water system are made of chemical insert materials

One very common problem of aquariums is the present of ammonia in the tank, which can arise from waste products excreted by the specimen and which is very toxic. One economical way of getting rid of this is by taking advantage of the bacteria that change ammonia into nitrate. Although this bacteria occur naturally in tanks, the amount is not sufficient and biological filtration is a proposal since countless numbers nitrifying bacteria live of the grains of sand or the gravel of the filter bed. Since nitrifying bacteria need oxygen, the water need to be aerated before and after filtration. Other harmful substances can only be gotten rid of by replacing part of the water at regular intervals.

Increase in acidity in aquarium water is produce by oxidation (which acid producing process, hence the for the water to alkalized to prevent acidosis.) Therefore the water is kept in close constant with some form of calcium carbonate e.g. Marble chips calcite or shells.

In conclusion, proper aquarium water quality depends on: -

1) The use of chemical inert materials.
2) A suitable source of water.
3) Adequate circulation, aeration and filtration.
4) Cleanliness – by avoiding over crowding and over feeding.
5) Control waste product by filtration, alkalization and dilution.

8.3.3 GENERAL PLUMPING

All museum facilities such as the administrative area and all others including the galleries will employ the use of domestic plastic pipes (PVC) from the university mains supple and from the basement area tank, which supplies the galleries 15,000 gallons cap. The same type of pipes will connect to WC's, kitchenettes and work areas to the soakaway. The roof gutter will be drained to the ground gutters by PVC pipes.

8.4 DRAINAGE AND SEWAGE DISPOSAL

8.41 Roof drainage and surface water drainage

With regards to building on site and roof type proposed to be used, areas where concrete parapets are used, are laid to fall into rain water pipes, which are connected, to a back inlet gulley, which discharges into the drain. Pavedarea are laid to gradient gullies which collect water and drain into the main external drainage system towards the lagoon.

Drainage round the site shall be by the construction of a major concrete channel, which would collect and transfer the bulk water directly to the Lagos lagoon bounding the site.

8.42 Sewage disposal

The waste disposal within the buildings is achieved by the use of a multi-stack system. This would access all forms of waste (discharges) into the sockaways located outside the buildings with adequate ventilation pipes connected to the stack system to reduce the pressure fluctuations which may lead to induced sighonage or back pressure. All the vertical pipes with discharges from toilets and rooms shall be connected to the inclined horizontal soil pipe in the service chamber which will be accessed from outside, draining the discharges into the combined drain. There shall be inspection chamber also located at the end of each system before leading into the combined drain.

8.5 REFUSE DISPOSAL

This shall be through the use of chutes located at various points on the site. The contents are collected at one journey by the waste disposal board using the refuse collecting vehicles, which disposes properly of the collected waste.

8.6 ACOUSTICS

8.61 Noise control by zoning

Two minor roads presently run around the site which apparently are the major sources of noise. Considering this factor resulted in the location of the buildings far away from these roads since forms of lecturing are going to be carried out in the buildings so as not to create an interference between the noise from the roads which are unwanted and the noise from the building which are acceptable.

8.62 Noise control by the use of sound- proof materials.

The major material used in noise control are buffers (trees) which therefore means that these controls are majorly located outside the building at particular locations on site. This is to prevent and enhance noise control from minor sources around the site including the control of major noise sources.

Since the functions carried out inside the building are similar, noise control within the building there proves unnecessary

8.5 FIRE SAFETY

Fire extinguisher are located at strategic points in the museum, especially in the outdoor restaurant, which has a kitchenette, in the basement for the research lab and

CONCLUSION

All materials needed for the construction of both buildings can be locally soured and are readily available. A professional must carry out the supervision of the units and the entire building should be handed over to a facility manager for maintenance.

In a situation where there is a need for expansion and provision of more aquariums, this can be done vertically as the entire roof of the exhibition hall can be dismantled and more floors can be created vertically.

This proposal can be located in any state of the Federation but must be close to a water-body. The water-body can be of any sort either sea water, brackish water or fresh water. In specifying aquariums for particular fishes, there must be a careful study and selection of the fishes, which would be kept in the same aquarium so as to avoid death of destruction of the fishes or aquarium.

Funding of this museum must be prompt and adequate and the staff must be provided with all necessary materials, information and education that would aid in protecting and preserving the entire facility.

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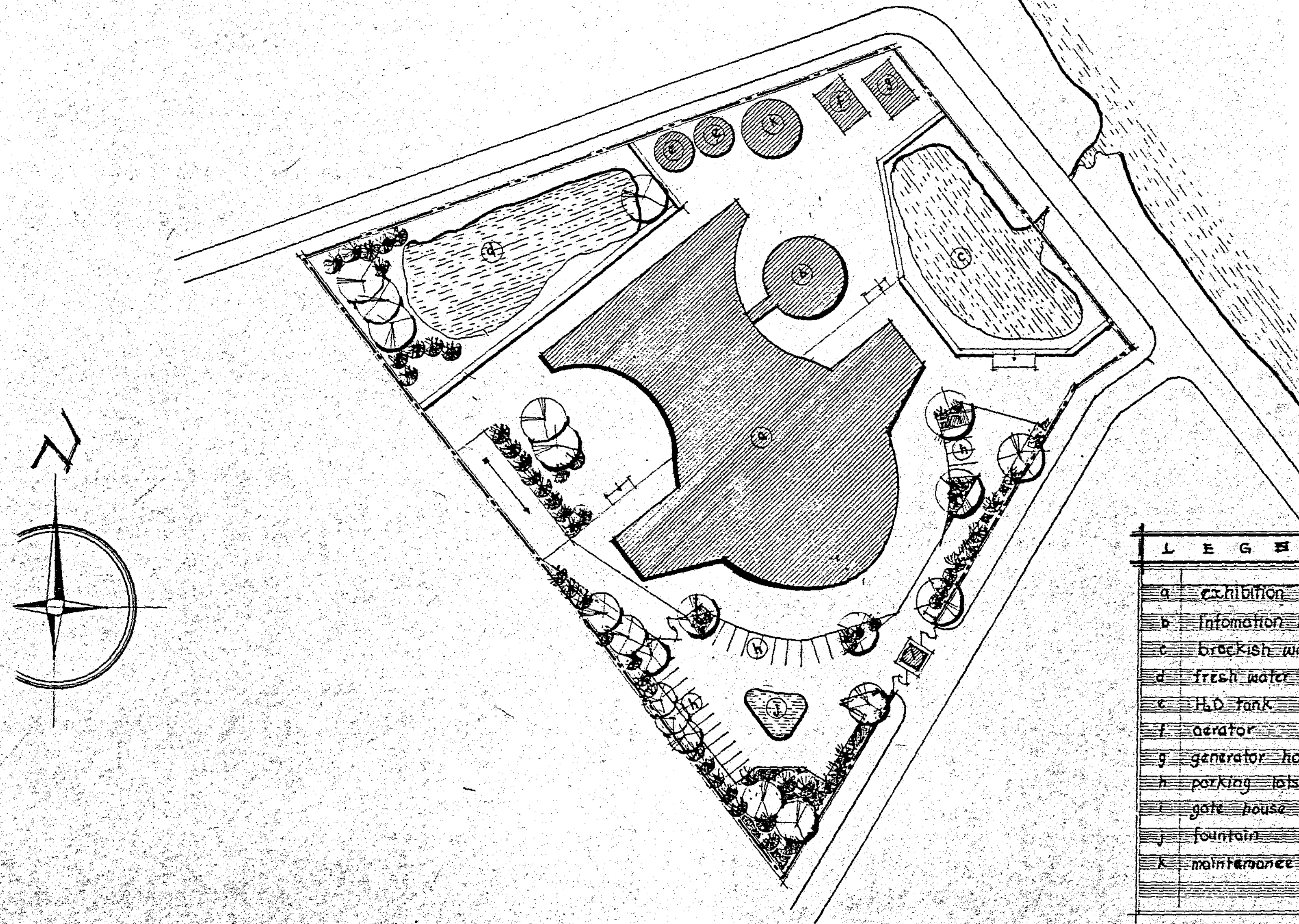
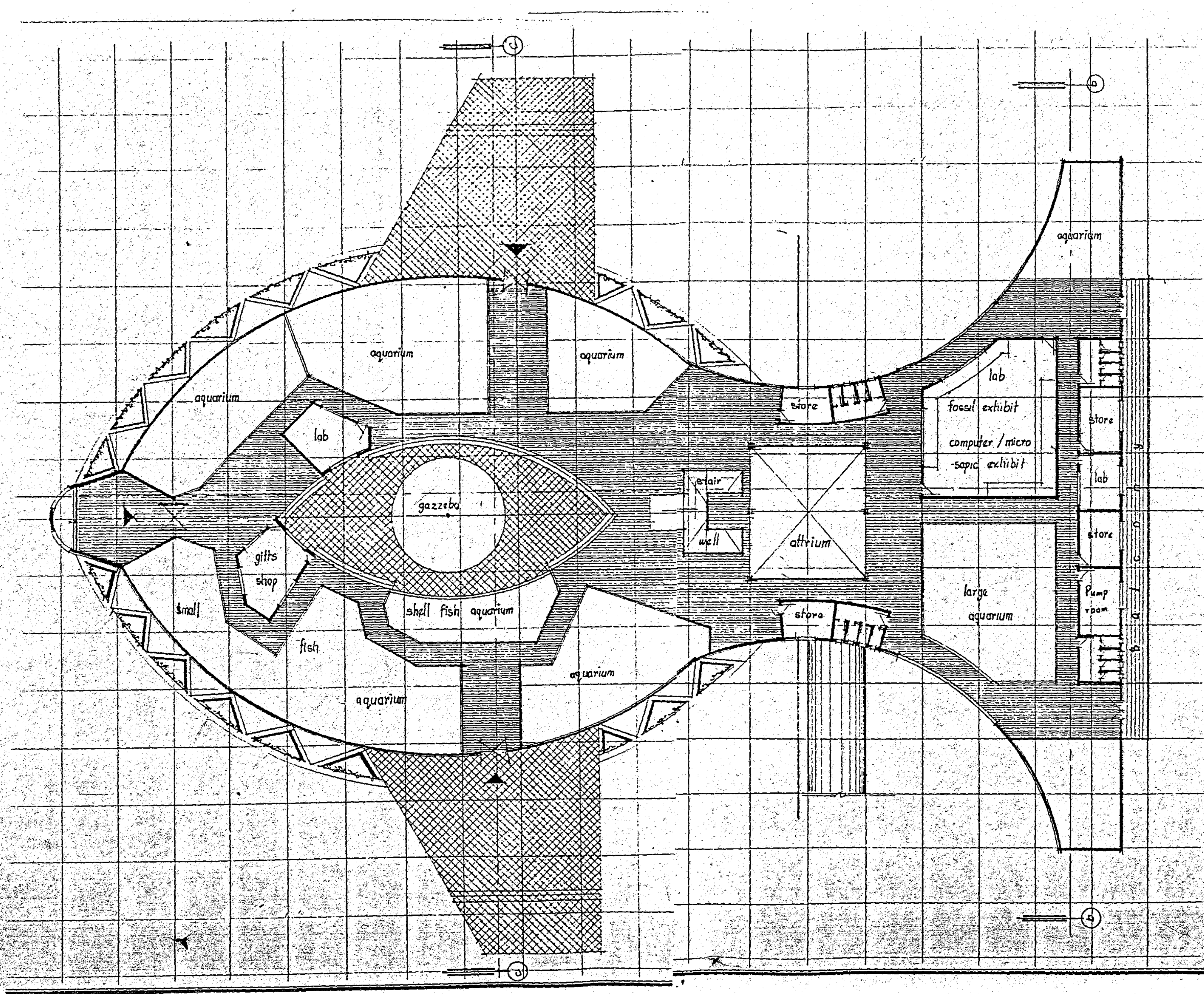
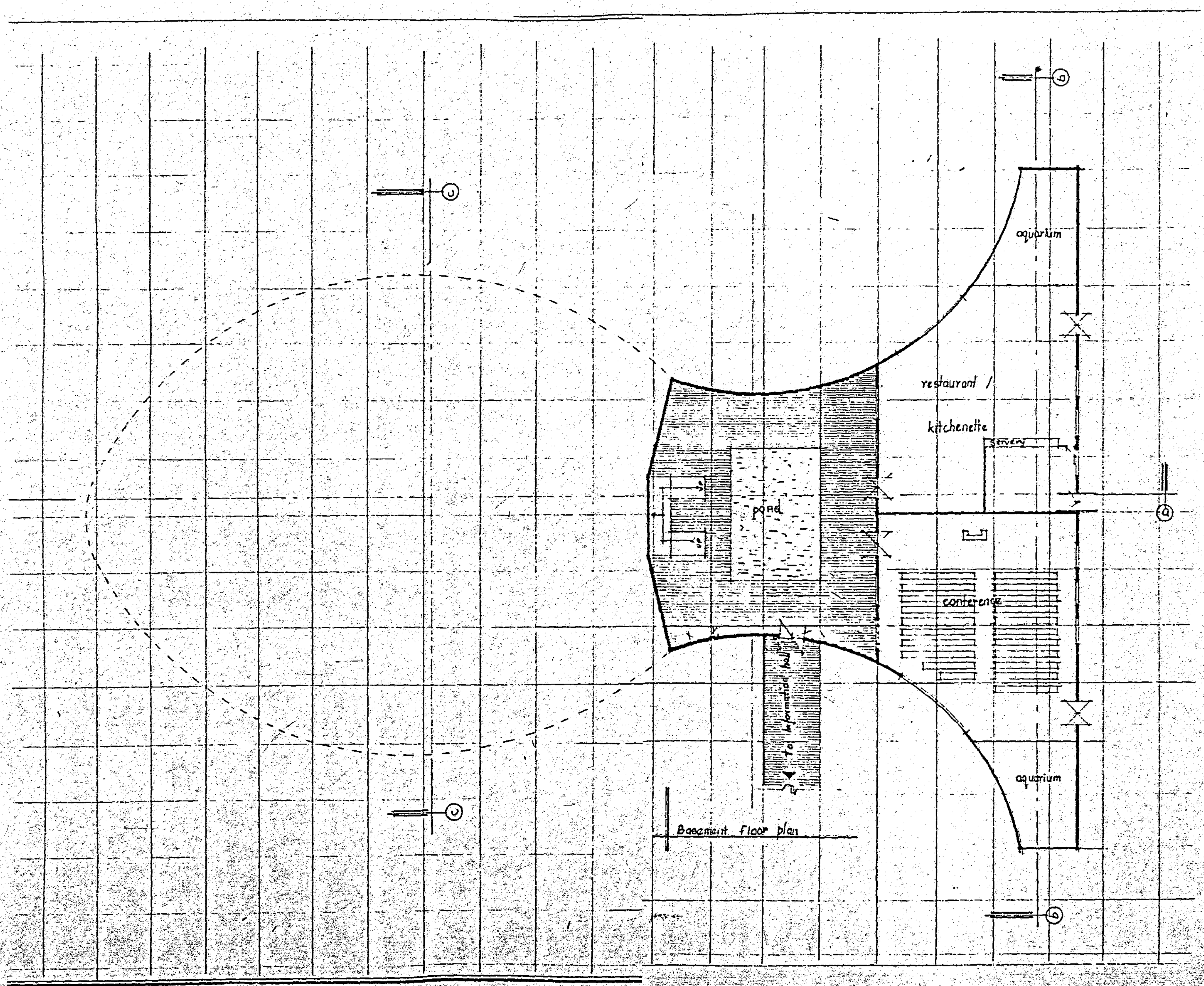
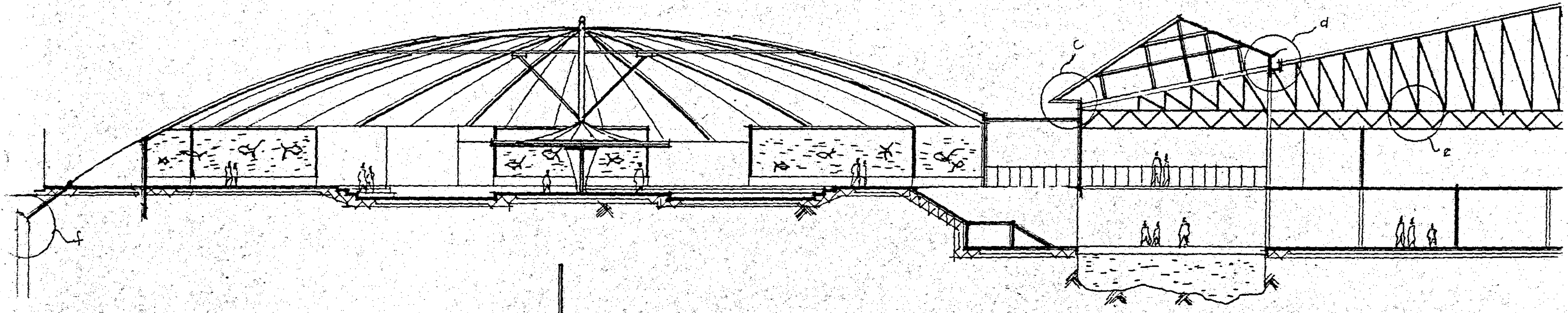


L E G E
a exhibition
b Infomation h
c brackish wa
d fresh water
e H_2O tank
f aerator
g generator hou
h parking lots
i gate house
j fountain
k maintenance

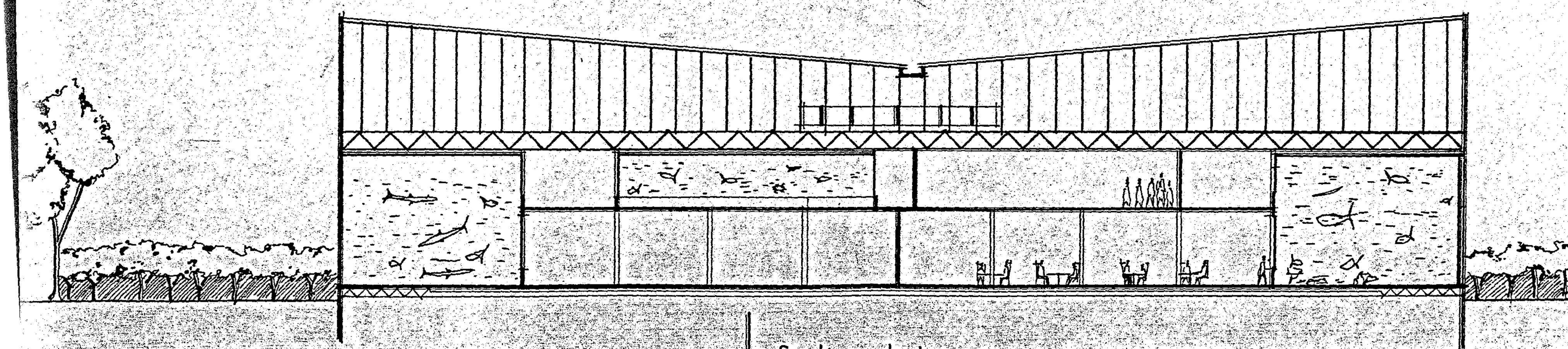


aquarium
aquarium
aquarium
aquarium
lab
gazzebo
gifts
shop
small
fish
aquarium
shell fish aquarium
aquarium
stair
well
attrium
store
store
lab
fossil exhibit
computer / micro
-sapic exhibit
store
lab
store
large
aquarium
Pump
room
balcony

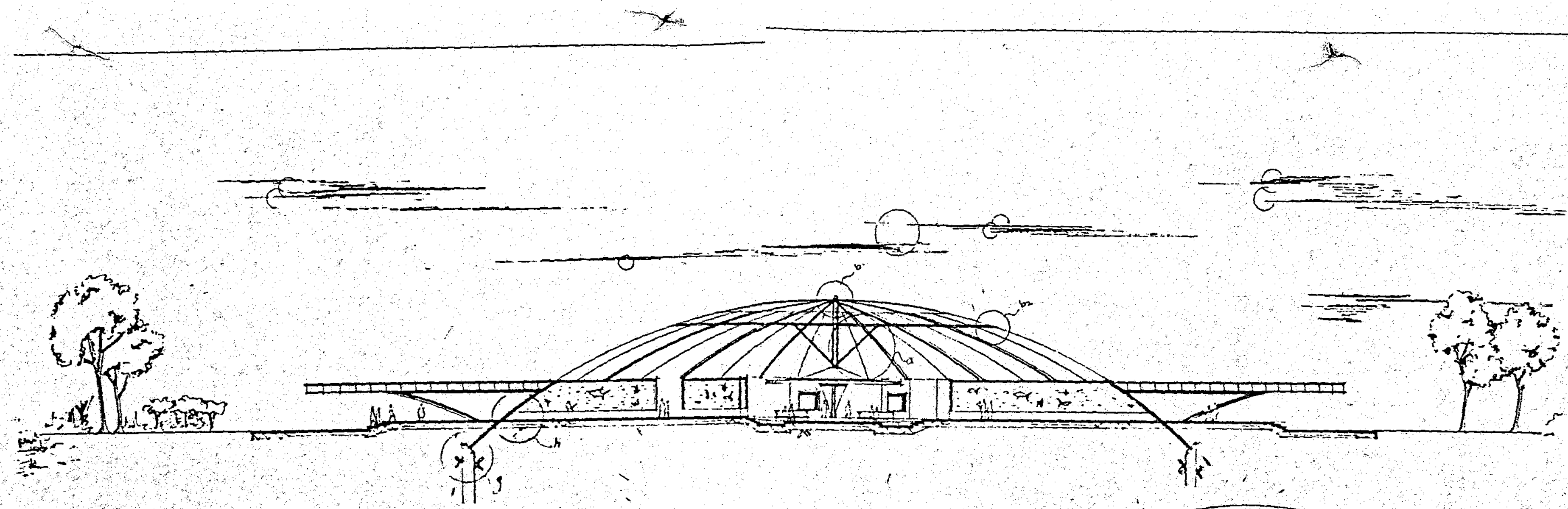

aquarium
restaurant /
kitchenette
servery
pond
conference
To information hall
aquarium
Basement floor plan

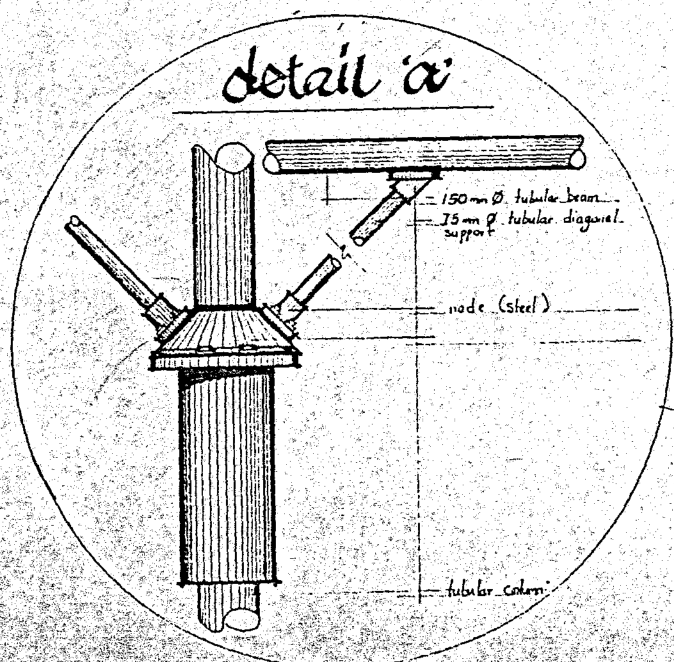


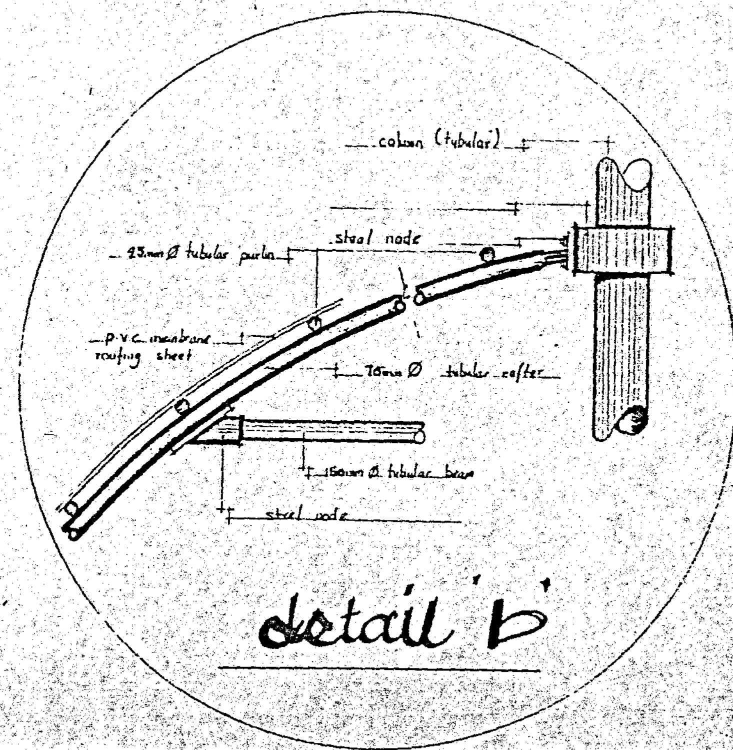
Section a-a

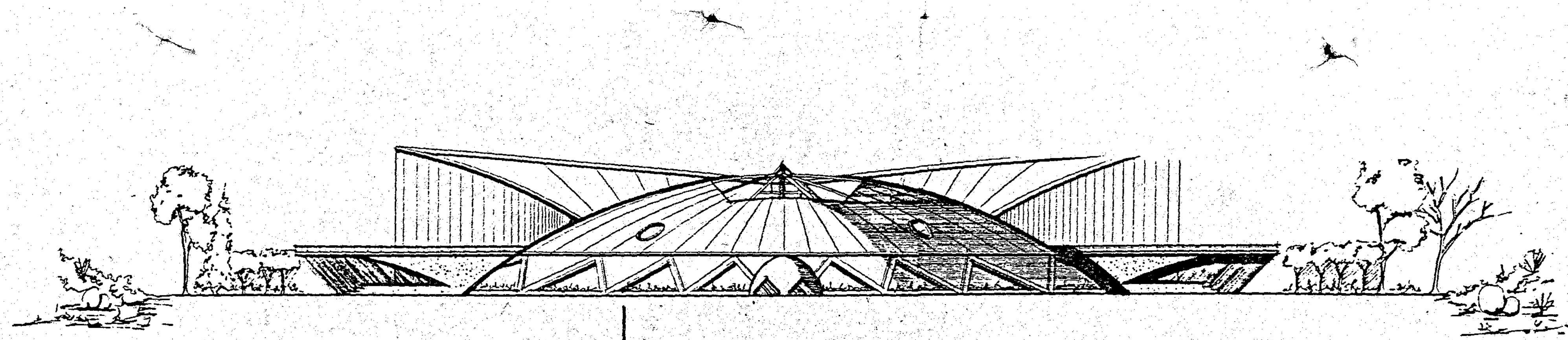


Section b-b

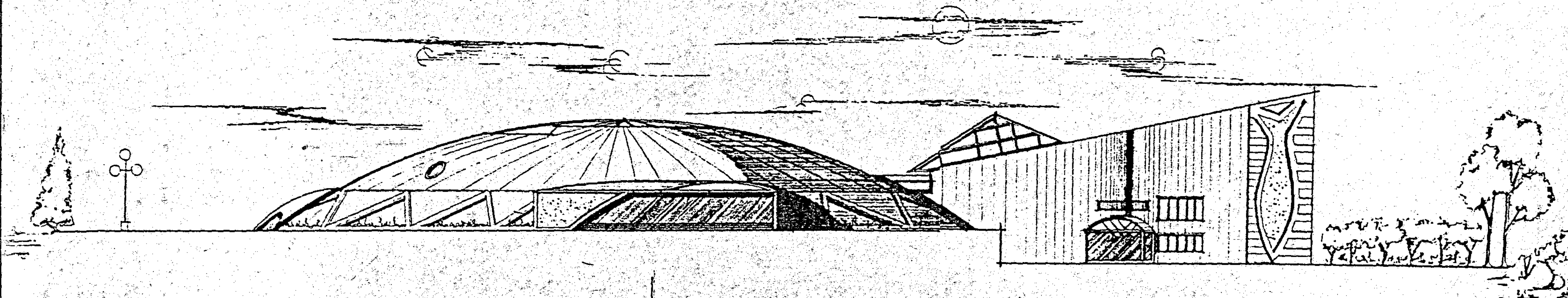



detail 'a'
150mm Ø tubular beam
75mm Ø tubular diagonal support
node (steel)
tubular column

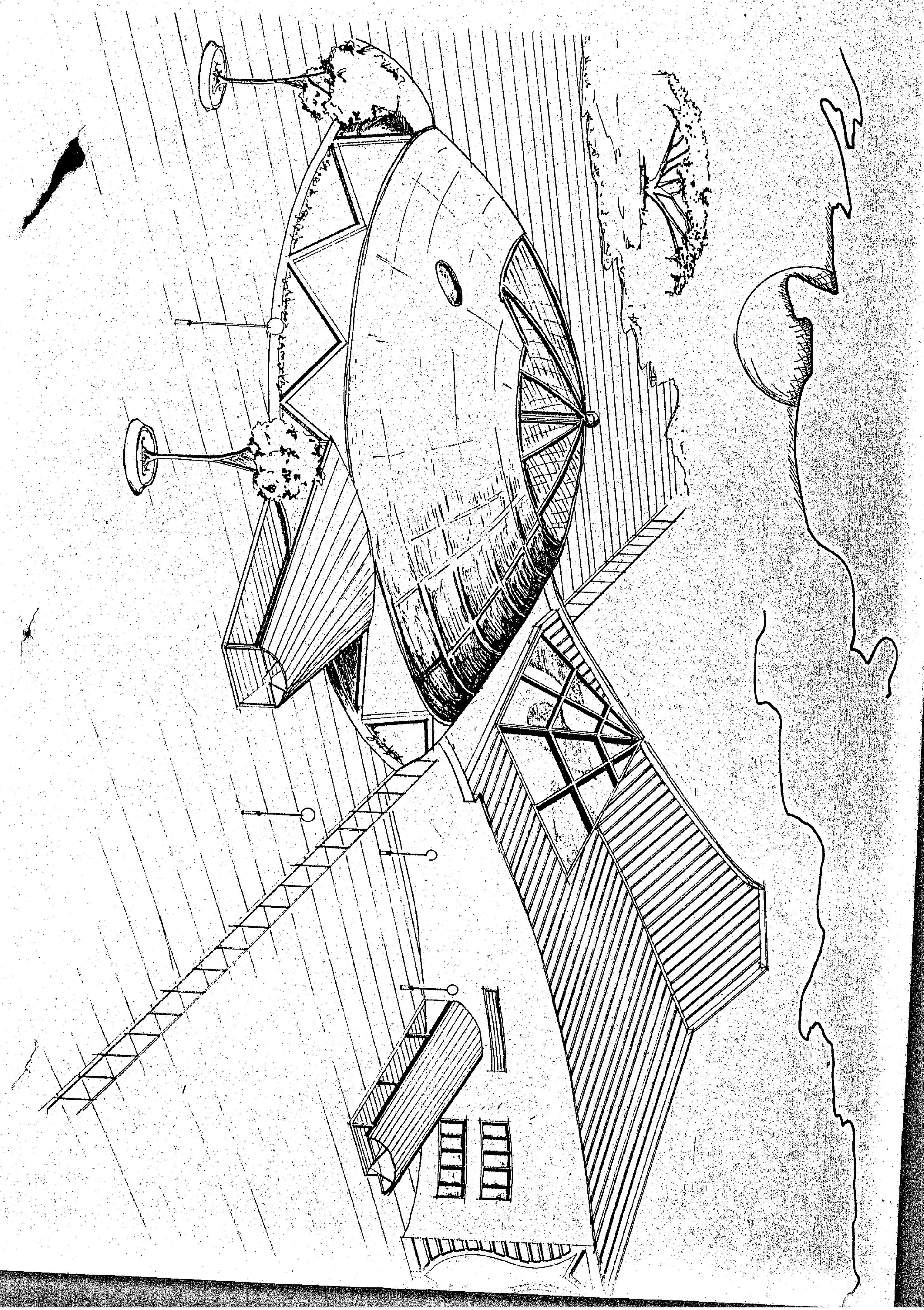

column (tubular)
steel node
23mm Ø tubular purlin
P.V.C. membrane roofing sheet
76mm Ø tubular rafter
150mm Ø tubular beam
steel node
detail 'b'

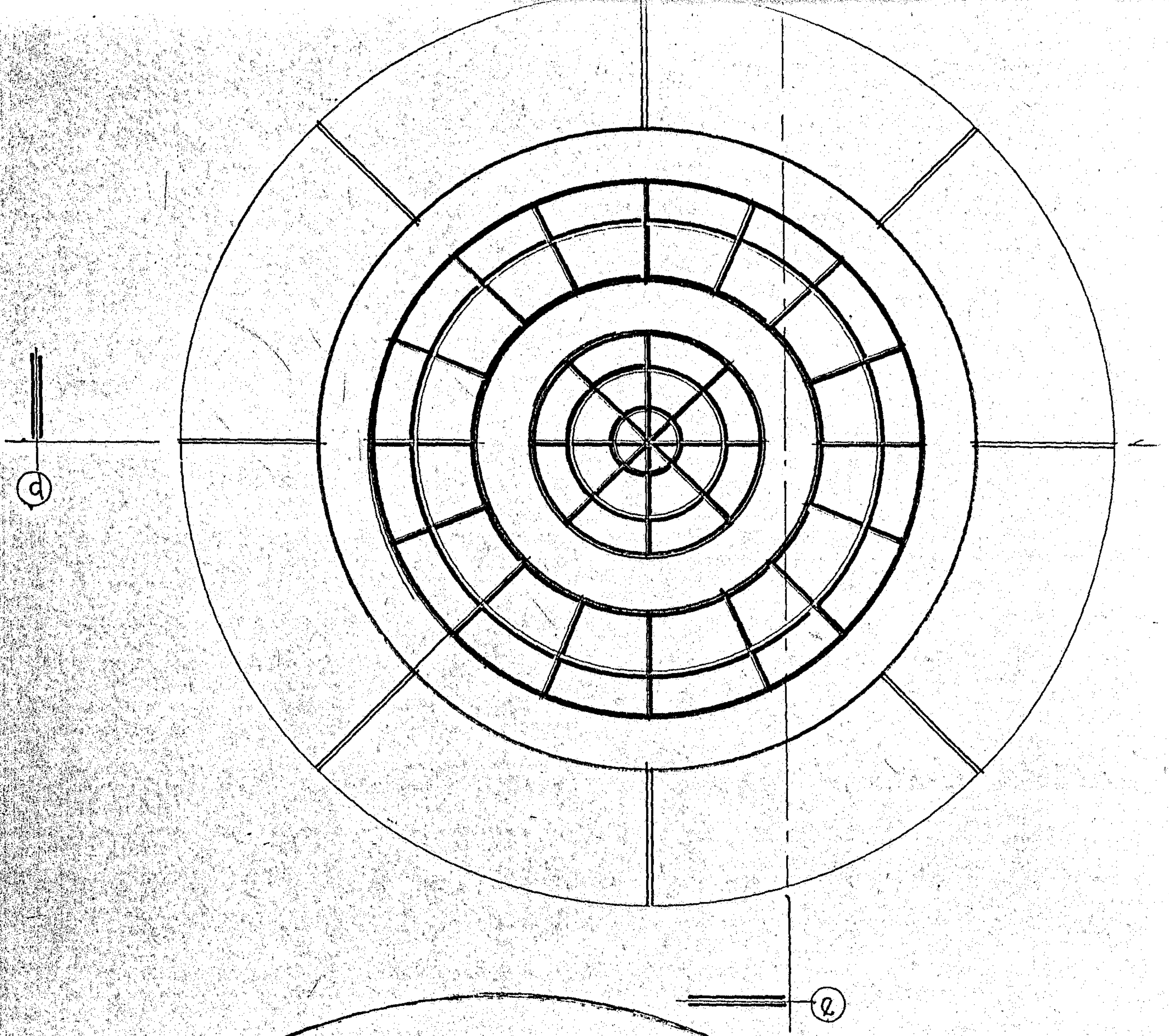


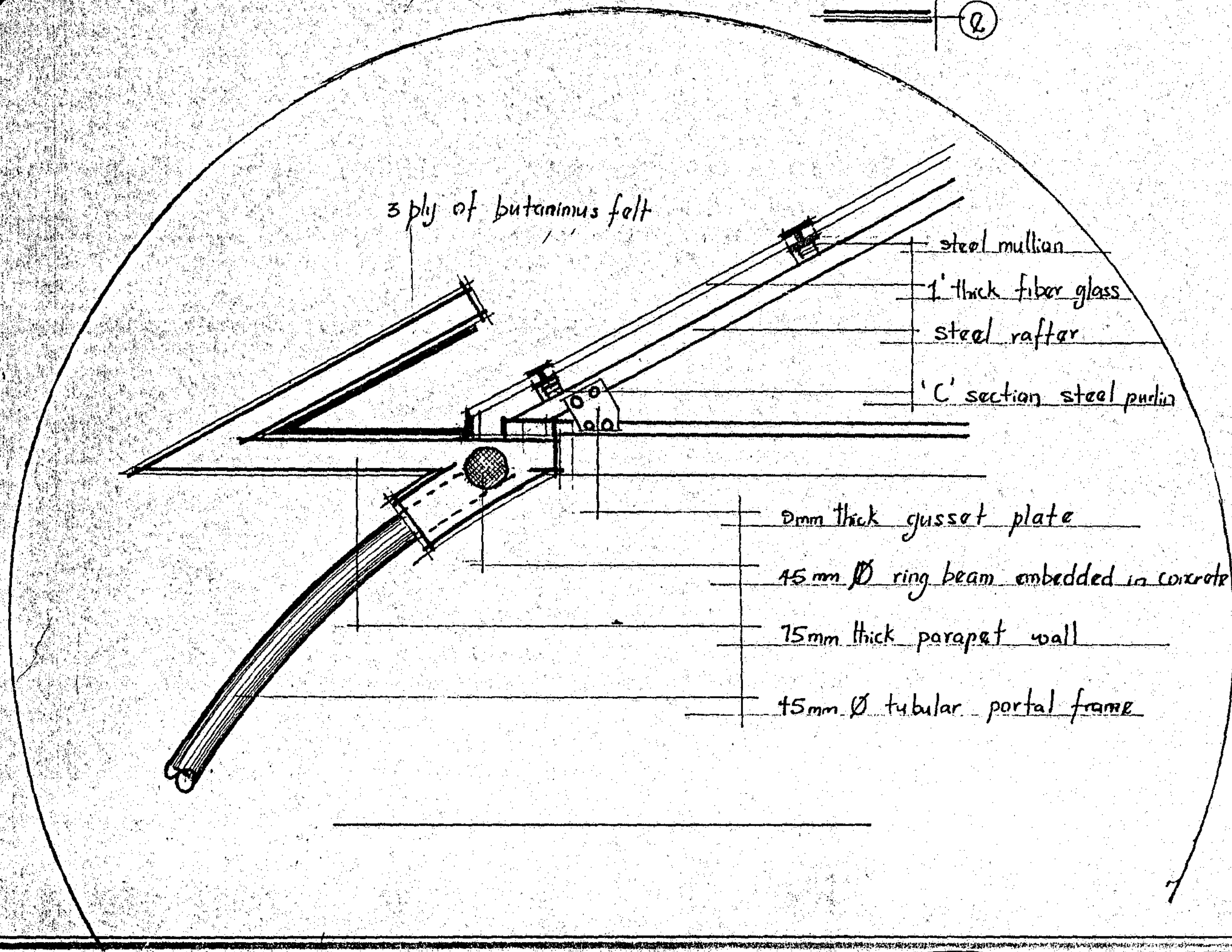
approach elevation



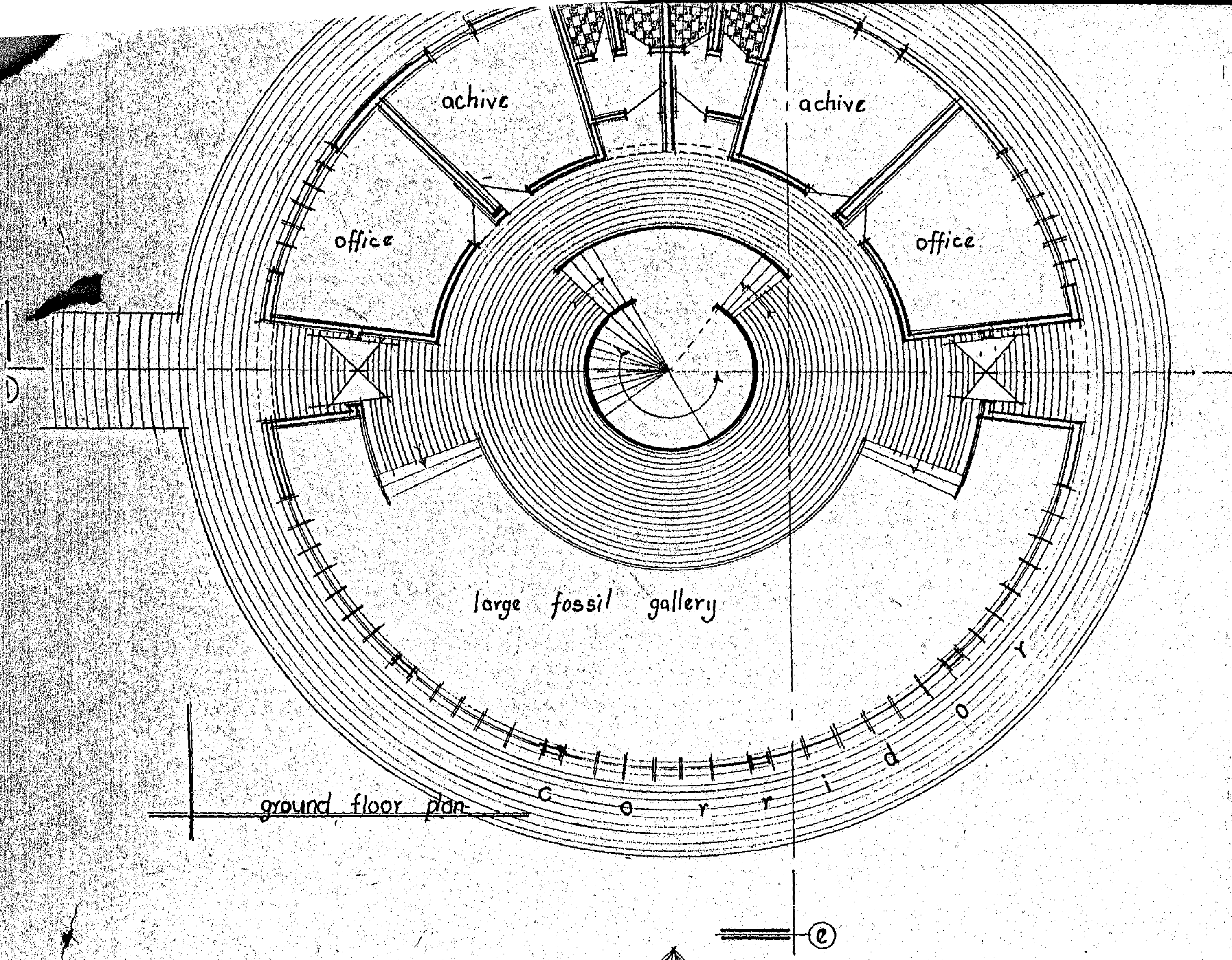
right side elevation



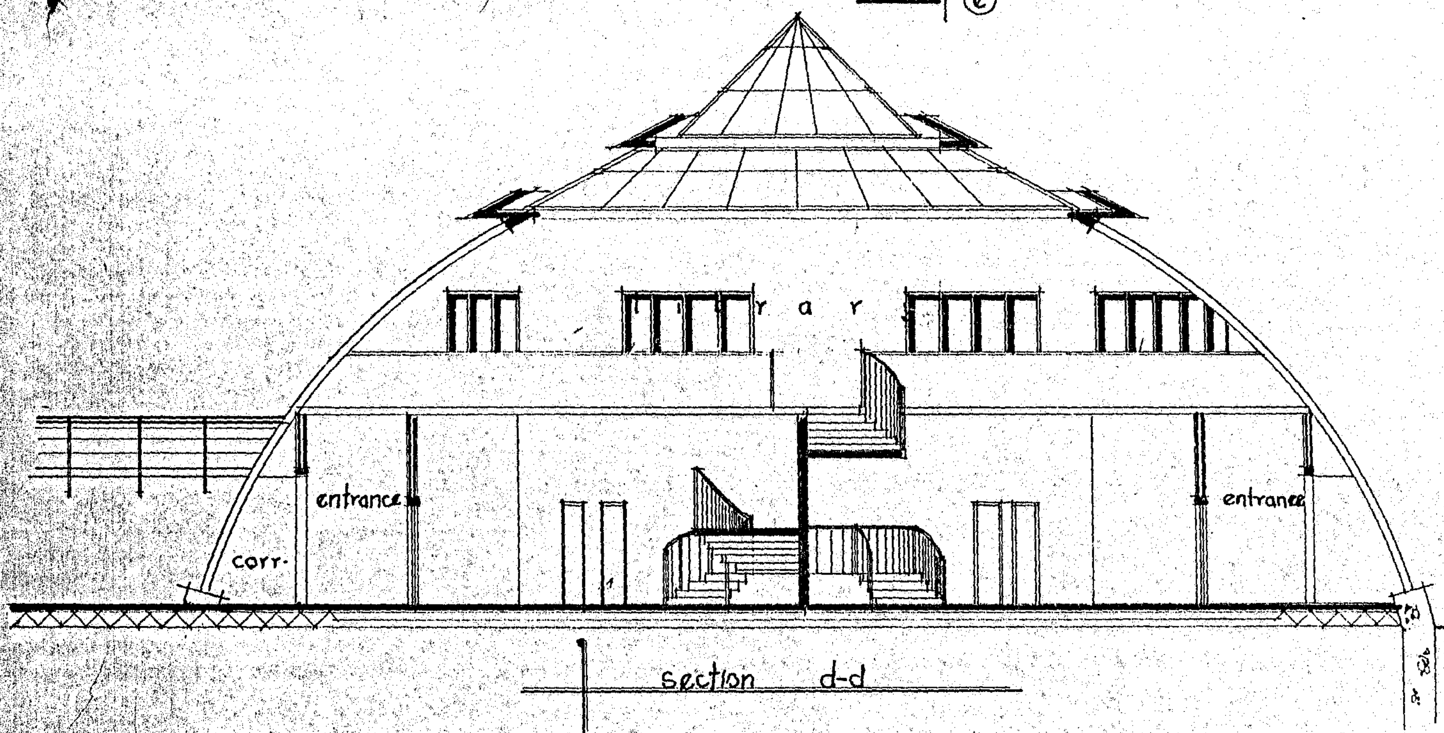

d
e


3 ply of butaninus felt
steel mullian
1' thick fiber glass
steel rafter
'C' section steel purlin
8mm thick gusset plate
45 mm Ø ring beam embedded in concrete
75mm thick parapet wall
45mm Ø tubular portal frame

7

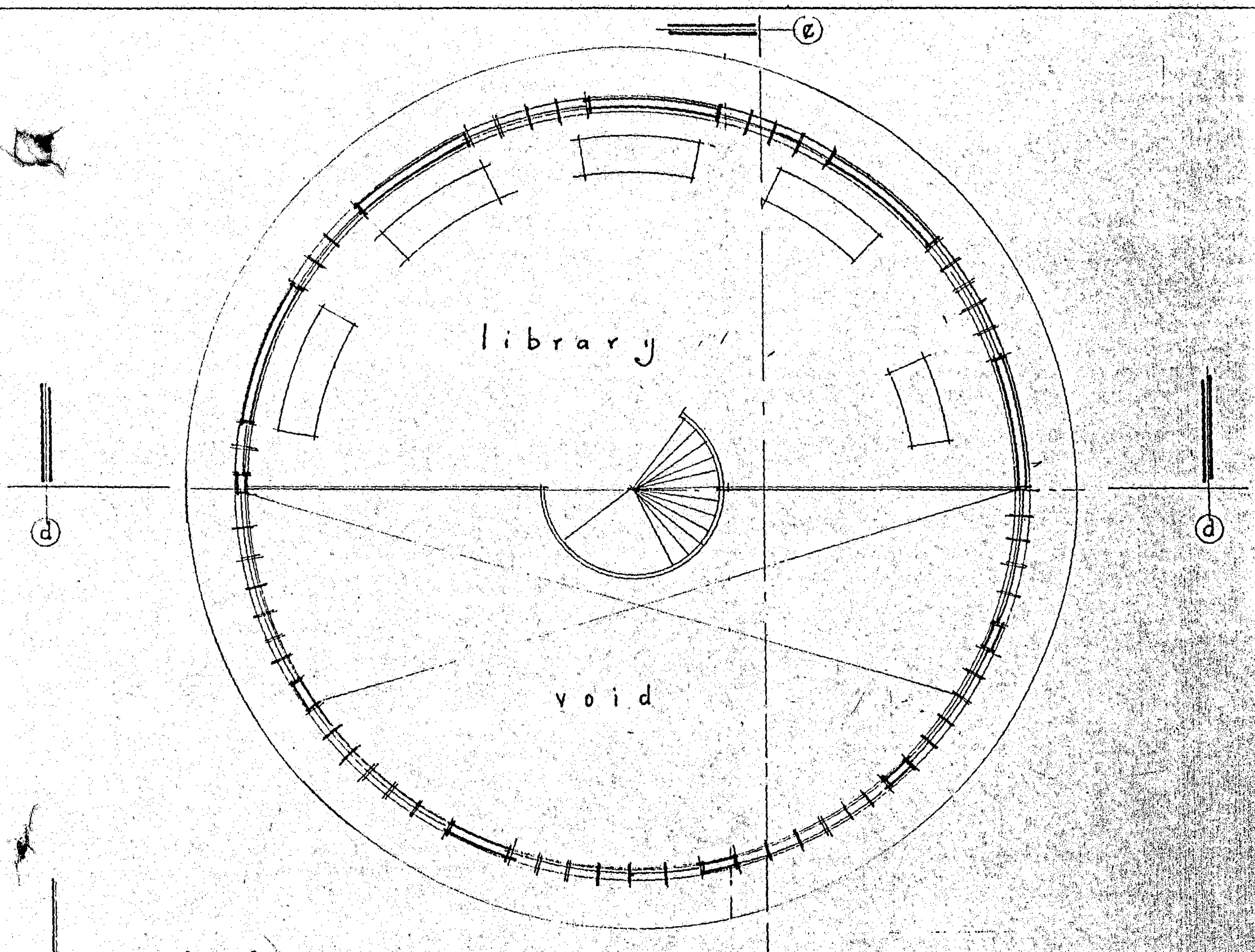


ground floor plan

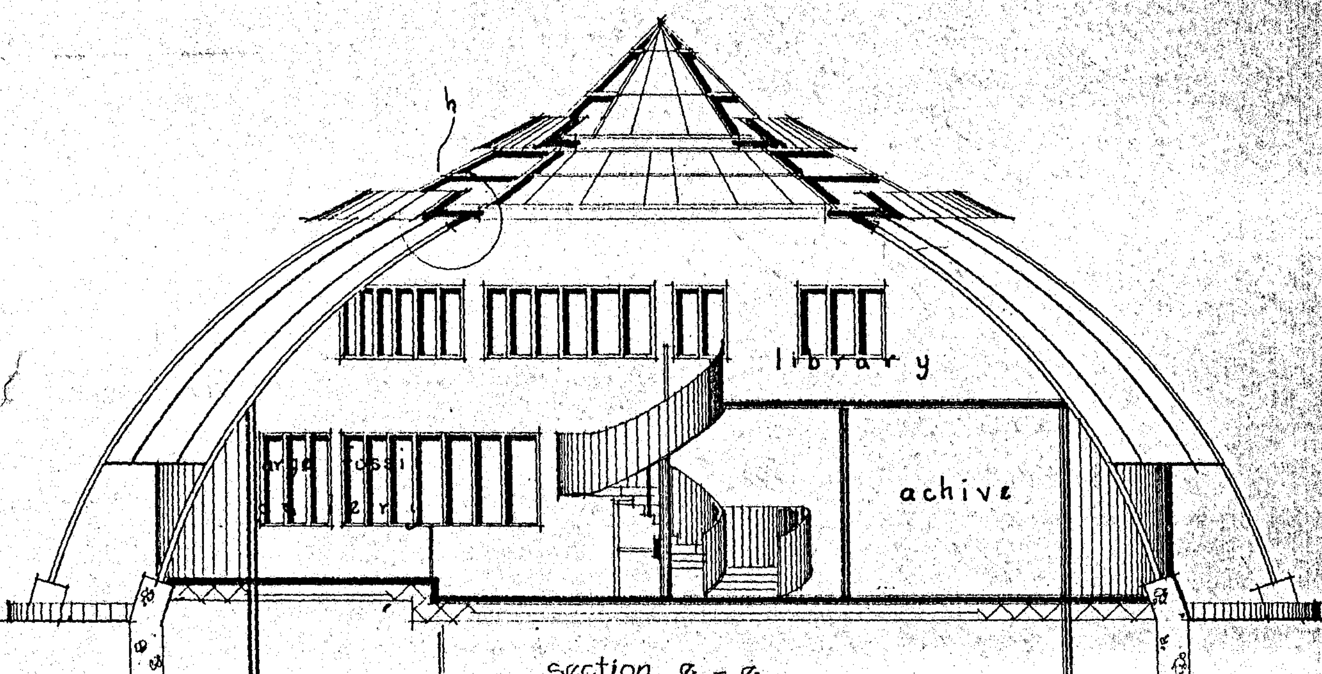


section d-d

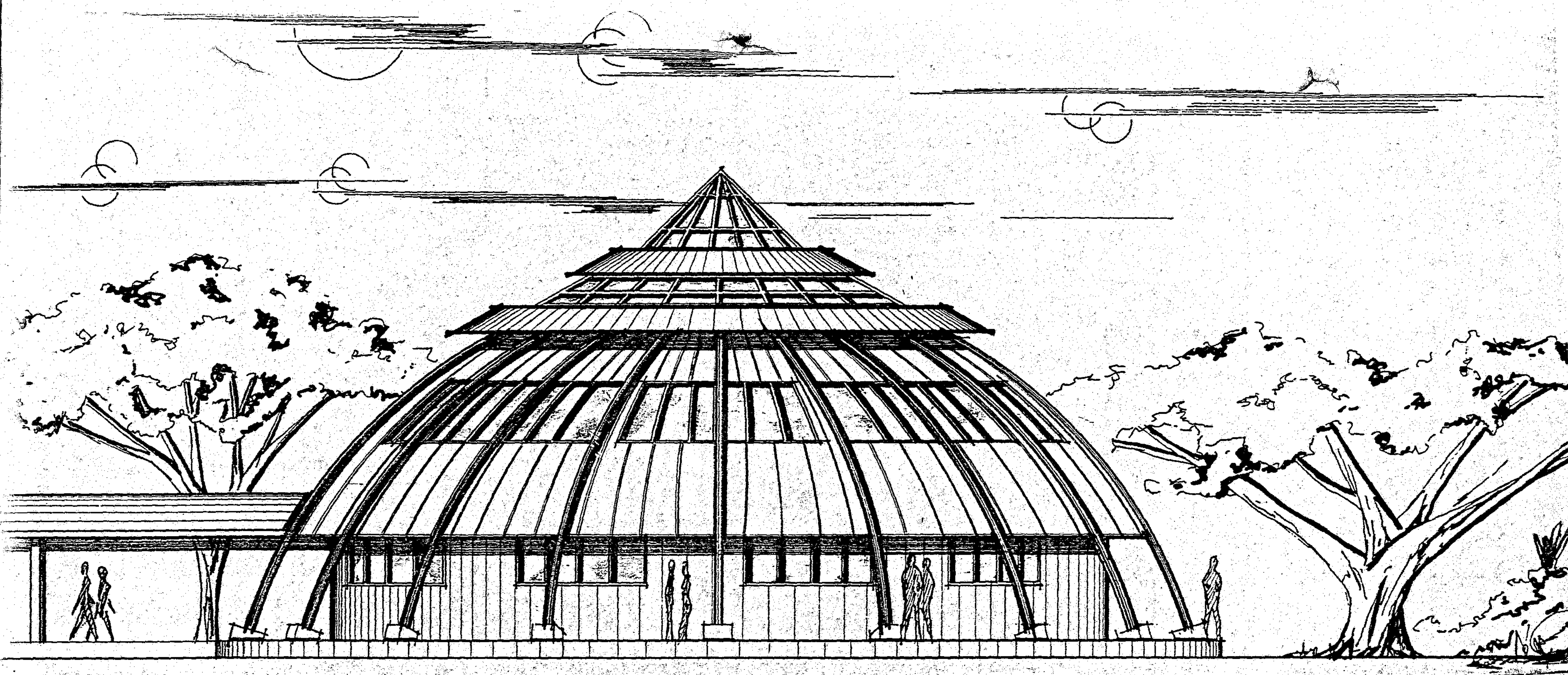
DESIGN PROPOSAL FOR A MARINE



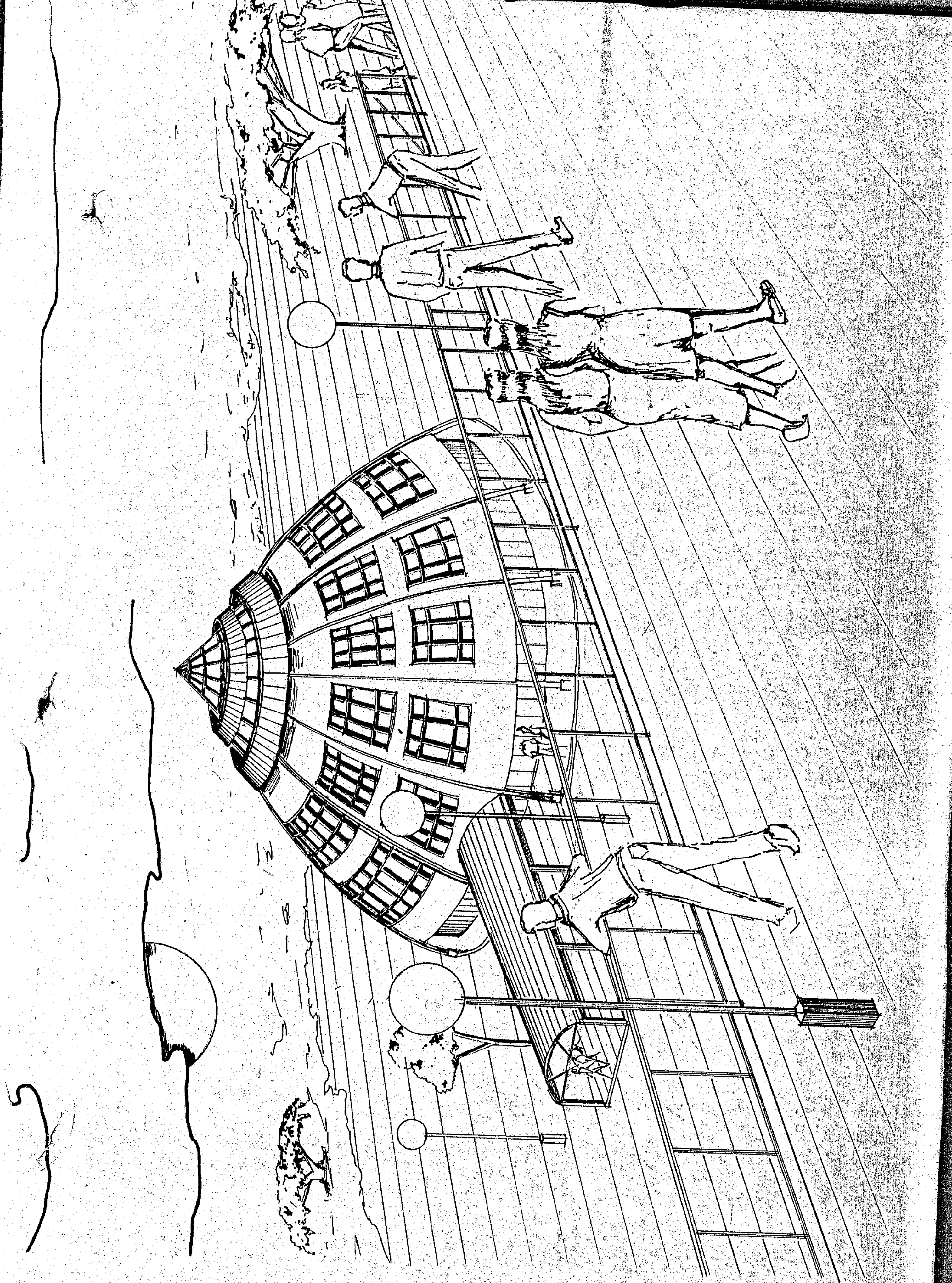
mezzamine floor

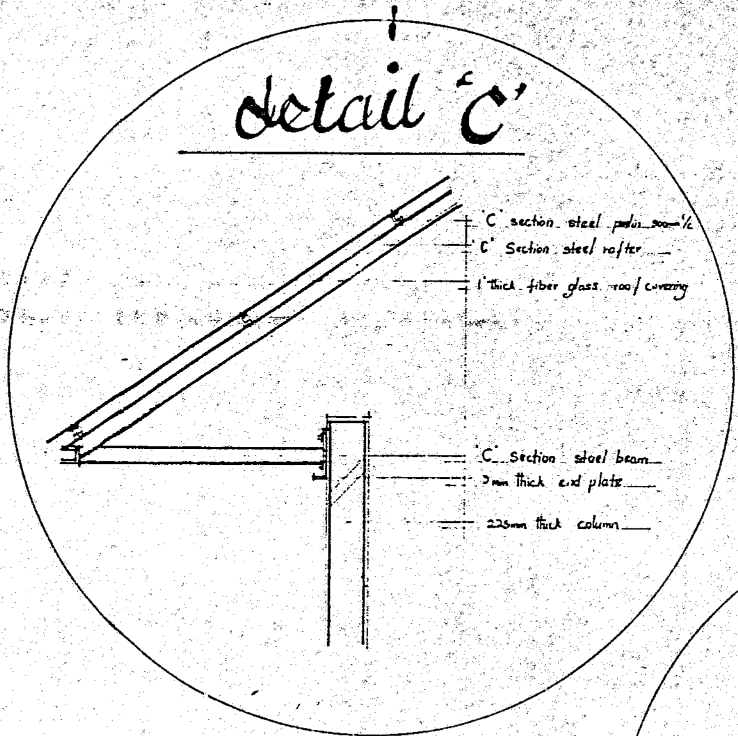


section e – e

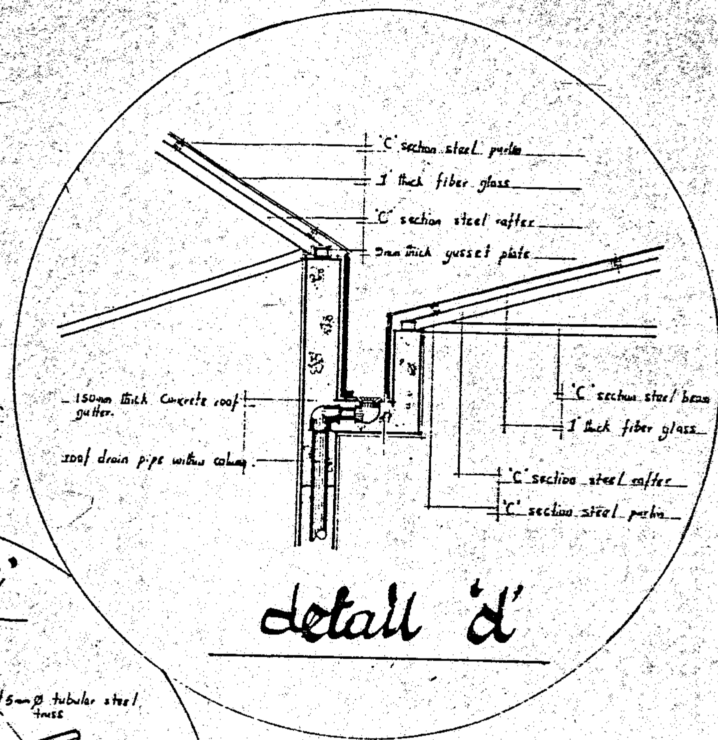


front elevation

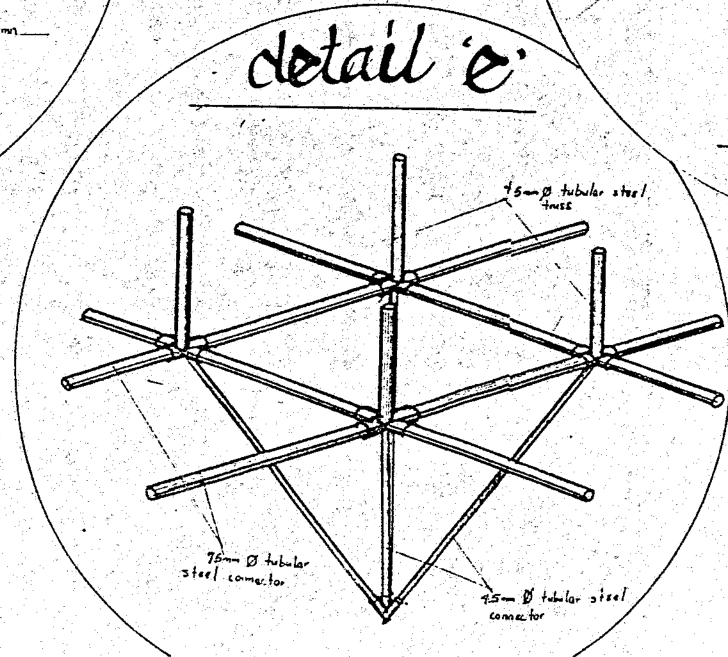




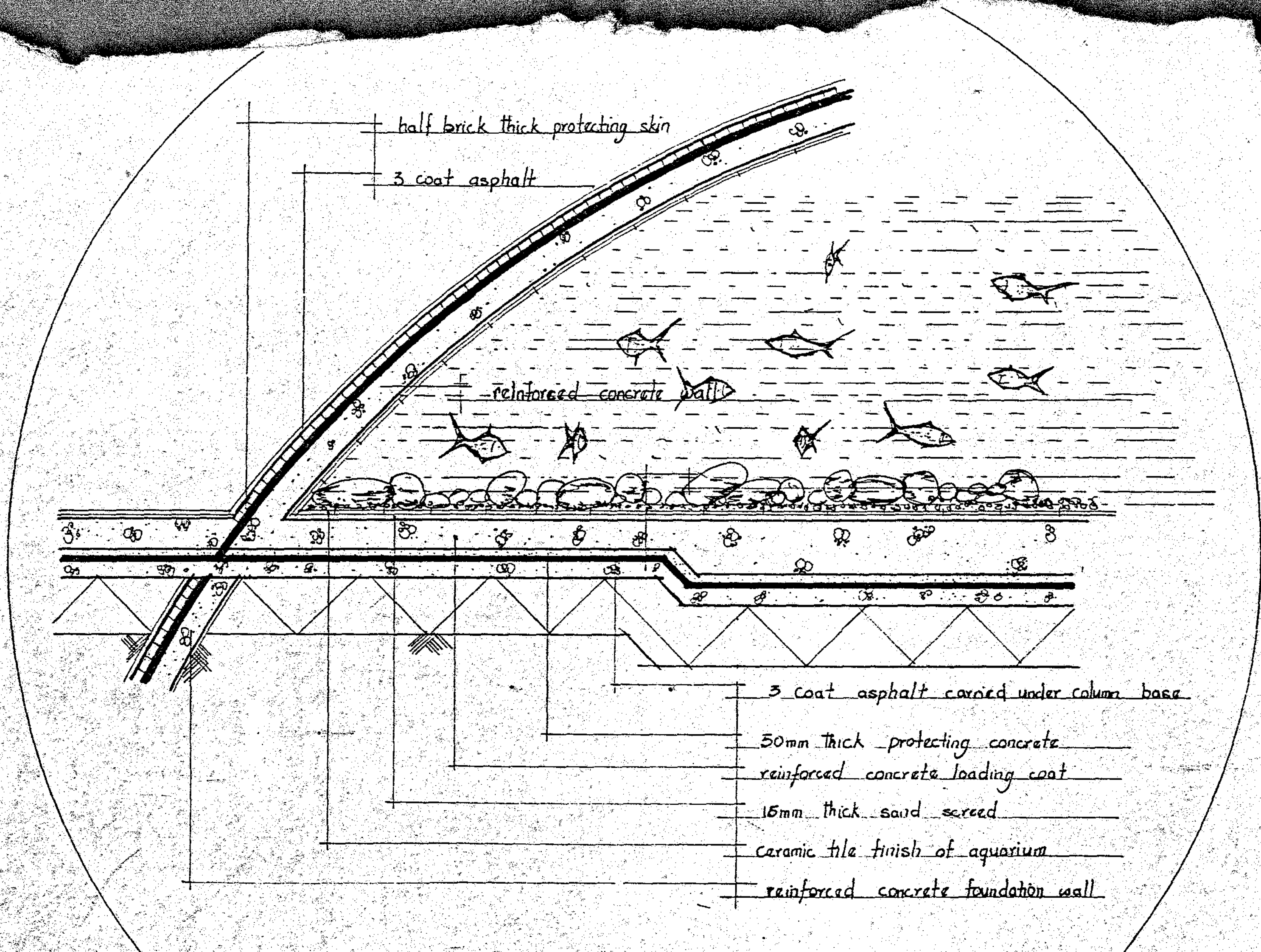
detail 'C'
'C' section steel purlin 900mm c/c
'C' Section steel rafter
1' thick fiber glass roof covering
'C' Section steel beam
3mm thick end plate
225mm thick column



'C' section steel purlin
1' thick fiber glass
'C' section steel rafter
3mm thick gusset plate
150mm thick Concrete roof gutter.
100Ø drain pipe within column.
'C' section steel beam
1' thick fiber glass
'C' section steel rafter
'C' section steel purlin
detail 'd'



detail 'e'
75mm Ø tubular steel truss
75mm Ø tubular steel connector
75mm Ø tubular steel connector


half brick thick protecting skin
3 coat asphalt
reinforced concrete wall
3 coat asphalt carried under column base
50mm thick protecting concrete
reinforced concrete loading coat
15mm thick sand screed
ceramic tile finish of aquarium
reinforced concrete foundation wall

detail 'h'