A MULTI-PURPOSE AUDITORIUM COMPLEX FOR AHMADU BELLO UNIVERSITY, ZARIA

(An Architectural Investigation into the Use and Aesthetics of Cable Structures)

BY

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ARCHITECTURE

DEPARTMENT OF ARCHITECTURE FACULTY OF ENVIRONMENTAL DESIGN AHMADU BELLO UNIVERSITY, ZARIA

JULY, 1987

DEDICATION

This Thesis is dedicated to my Late father Mallam Laminu Abdulrahman (A professor in Arabic Theology) who sees education as the limit of human development, and to my mother Hajiya Kolo Laminu Zarigana.

ACKNOWLEDGEMENT

"To plan for a season you grow plants, to plan for years you grow trees and to plan for decades you educate men" (A.B.U.)

Man cannot get the education required without the help of the people around him with whom he shares ideas. To this end I would like to express my profound gratitude to all my lecturers in the Department of Architecture who taught me one time or the other in the achievement of this noble objective. I would like to thank my supervisor Dr. Solanke and his assistants Arc. Onoba, Arc. Folabit, Arc. Channana who channelled their constructive criticisms toward my success. My earlier mentor Yinka Gbotosho is also remembered for his inspiration into my art of space perception and conception.

My attention goes to my brothers and sisters for their contributions both morally and financially. They are Abdulrahman, Yagana, Rakiya, Ayisatu, Halima, Rufai and my nices Abubakar, Amina and Jubril.

My thanks also go to Alhaji Yakubu Godabawa, Alhaji Saleh, Isa Tahir, Alhaji Gambo Gubio and Alhaji Gaji Galtimari who made all efforts to attend to my problems and also for contributing to the family's upkeep.

I wish to thank my state government (Borno state scholarship Board) for sponsoring my education up to this level. My special attention to Mallam Yakubu Mohammed of the scholarship board for handling all matters related to students problems.

My colleagues in school, too numerous to mention would also be remembered during the struggling period, and their criticism on subject matter related to architecture, they are Adamu G. Kareem A., Muktar A, Umar G, Madukife A., Miss Salihu, Miss Saad, and my juniors who showed concern in developing their architectural talents with me, they are Miss Ebaide, Mr. Awosanmi, Mr. Gyoh, Mr. Joseph, Miss Moji.

My typist, Mr. Timothy Obogbare should be given the credit for working relentlessly in making sure that all matters related to time are resolved and Mr. Halilu for producing my print works. Data room librarian, Mr. Elisha is remembered for his special assistance during the course of the project research.

The utilization of time within a space requirement would allow man to achieve his set out goals, to this end, the search for knowledge should allow man to go beyond the moon.

ABSTRACT

Space utilization within the 80s in Ahmadu Bello University has created the need to utilize the available resources at its disposal effectively. This problem has given the awareness to the administrators to understand the use pattern of the community (students and staff).

To understand the use pattern, facilities both social and academic were surveyed as reported in the master plan proposal scheme. The report showed that the upsurge in the campus population has demanded the need to make available those facilities necessary to permit the good operation of the campus system.

A multi-purpose auditorium complex is therefore proposed to accommodate the social and academic requirements of the community and to also operate as an autonomous institution where revenue would be generated from the auxiliary facilities that would be provided within the complex.

The introductory chapter shows the problem definition of the thesis and also looked at the contributory part of the thesis which is mainly theatre planning by understanding the intricate roofing elements which directed the researcher to make a research into the use of tensile structure. The research looks at the advantages, problems form, structures, aesthetics, economy and the limitation of tensile technology.

Chapter two has tried to show the contextual development of theatre as an art both in Western and African idiom, and also to understand how the next generation of designers would draw a hybrid

space between the western and the traditional theatre for a true regional theatre architecture.

In chapter three various parameters to theatre planning were analysed, this include the sight line, acoustics, acoustical materials, space morphology etc., all these components have become the guiding principle of the design.

The survey on recreational planning was analysed in chapter four, to see how various factors of design come into play in the execution of an effective recreational scheme. This looks at recreation in A.B.U, and also made recommendations on some planning defects.

The understanding of existing situation has brought in the case study technique treated in chapter five. Local case studies were analysed for a good planning system.

The technological aspects of the theatre's roof was treated in this section (chapter six). This looks at problems, design, economy and limitations of tensile technology.

Chapter seven presented the existing structures utilizing cable technology, this has helped in understanding the caution to be taken in designing one.

The need to understand the local conditions of the site is necessary so that design would have to respect these local conditions. Chapter eight has tried to show how the site local

conditions were; these are, winds, temperature, humidity, sunshine hours, rainfall etc.

The last chapter is a treatment of various design approaches in architecture as applied to the thesis. This has gone to conceptual planning level, concepts evolution and site planning scheme.

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CHAPTER ONE

INTRODUCTION

The adjacency of facilities and their utilization have become the prime objective of the proposed Ahmadu Bello University master plan scheme which aimed at correcting existing planning defects. This discrete line of defect as foreseen by the University administrators gave birth to the feasibility studies on the existing facilities highlighting the role of the users in their operation.

After a careful study of these problems, it was discovered that facilities both social and academic were found to be inadequate looking at the trend of modern development. Within the study limit the proposal discovered that recreational facilities for social and educational intermingling was totally absent, thus a cultural centre was proposed to tackle these needs. As part of the objectives of the university's master plan to create a forum where students and staff from various cultural background interact, is therefore important to the projection of the university's image within a matrix culture. It is perceived that the culture of the university community would be antecedant to the country's multi dimensional cultures. So the amalgamation of cultural norms through learning facilities shall be unique in its apprehension.

As part of the physical strategy of the master plan proposal to develop the new campus southward of the existing

facilities, 20% has been given as the land mass area to provide for the recreational activities comprising, cultural centre, sports and convocation, 5% of this area is alloted to the auditorium complex that would cater for the cultural needs of the university.

The auditorium complex as conceived shall be the focal point of the new campus when fully realised and shall generate its population within the catchment area looking at the physical strategy of the master plan scheme. The population distribution of the extension scheme is comprised of students, staff and other members of the community. To this end, a summary breakdown of this population shall be of utmost importance to this project, because of its location in Samaru campus, the administrative headquarter of Ahmadu Bello University facilities throughout the federation. The breakdown of students and staff population shall highlight their role in the campus population distribution.

Ahmadu Bello University was broken down into various campuses due to its policy on extension of education to the inner core system. To this end, there are the Samaru campus, Institute of Administration campus, ATC Zaria campus, old teaching hospital campus and other affiliated schools around the federation.

The breakdown of the population (staff and students) in various campuses shows, that in 1980 - 81 survey 75.19%, 13.94%, 7.77% reside in Samaru, Administration and ATC respectively. The breakdown in 1985 shows Samaru,

78.22%; Administration 11.71%; and others, 18.07%. The projection by 1995 is expected to be Samaru, 80.11%; Administration, 11.49% and others 14.4%. On the average the students form 75% of the population in various campuses. This breakdown expresses the continuum variation of facilities within these campuses.

The centre of cultural studies within the campus is expected to play a key role in the management and organisation of cultural activities in other to enhance the image of Ahmadu Bello University and the community at large. The English Department in collaboration with the cultural centre could organise a research venture to create talents and awareness in the dramatic circle of the country.

The necessary facilities for an efficient functional dispensation shall be provided and awareness created through activities generation.

1.2 Project Definition

1.2.1 A multi-purpose auditorium

For a working understanding of the term used, the auditorium shall be defined according to Webster 20th century dictionary "as a building or hall used for speeches, concert etc." This definition shall show prominently the basic elements as thought of, and with a later development of the basic elements within the designer's scope.

The multi-purpose nature of the scheme is an enlightenment as conceived to show the demand level of the population in respect to taste for theatrical activities.

1.2.2 Sub topic

The sub-topic is titled "An Architectural Investigation Into The Use And Aesthetics of cable Structures." After a careful observation of the trend in architechtural development, it became imperative that an "emulsion" in terms of technological requirement should be sought for the complex nature of the roofing system. The background of the researcher and the need to solve other problems created the format for a thorough research into the field of cable technology.

To this end a closer look at various factors necessitating the selection of roof types and their acceptance by designers is viewed. These are:

a. To give a structure its physiognomy.
b. To emphasise depth through a harmonious use of elements.
c. To show aesthetics to those elements to be suppressed by proportion.
d. To arrive at an economic use of materials.

These and other factors are thought of in the selection of a roofing system.

Feasibility of cable structure through its manupulative tendencies and economy have created good judgement for the understanding of its basic technology in the field of aesthetic derivation.

Cable technology has been used in the field of architecture to show how space and expression could be built in a structure. The exploitation of these advantages have made architects to employ them in covering of stadia, auditoria, halls and other form of spaces. The major problems associated with this form of roofing are loadings, wind action and vibrations from external sources. Various factors of safety are considered to counteract these problems, this include damping against wind, prestressing against loading etc.

1.3 Definition And Identification Of Problem

The definition of the problem within the context of the research shall give the researcher views on how to tackle those problems and ways of achieving the set out objectives. The testing of a laid down hypothesis is a function of the research problem definition.

In his definition of problem Kalinger (1971) defined problem as an interrogative sentences or a statement that asks: what relationship exist between two or more variables? These variables within this definition shall be taken as those functions to be provided with a view of establishing intricate relationship between them. The manipulative tendency of the designer is an important factor in developing working variants. These major antecedants are identified in the problem difinition of the project.

a. Function.

b. Form.

c. Economy.

d. Time.

1.3.1 Function

In searching for function the designer tries to find out the activities that would take place within the complex in o order to provide those facilities necessary for their performance. The functions identified within the requirement are:

1. Threatrical performance of African origin and international origin.
2. Conferences, convention, symposia etc.
3. Fil.. show.
4. Fund raising.
5. Graduation ceremonies.
6. Prices.

1.3.2 Form

This relate to site, physical environment (Psychological), the quality of the space and construction.

a. Site: In working with the site the criteria for its selection must be properly worked with or provide those necessary to keep a facility functioning. The noise, pedestrian movement, landscape, ordinances, landmark etc. are the forces that must be coagulated for an effective site performance.

b. Environment: For a good environmental control of the site, forces governing its workability should be known such as micro-climatic, landform etc. This will go a long way in creating comfort zone of that area.

Quality

The functional quality of a building can be assessed in terms of its visual elegance as experienced by an observer. This looks at precinct constructional details, site planning concepts and other elemental factor of the assessment.

Economy

The economic consideration tries to look at the available resources for the execution of the project. This include the operation and life cycle cost.

Initial cost

This looks at the amount of revenue generated to embark on the project execution. The revenue generated from its operation would give an insight into lapses at the initial project conception.

Operational cost

The operational cost tries to look at the quality of job executed and the patronisation problem.

Time

The nature of activities provided would have to be viewed within the context of space and time. The time sequence shall be classified into past, present and future.

Past

The past problem as identified would let the designer study the historical past relating to basic problems solution.

Present

This looks at the present technological development within the modern would of theatre performance.

Future

The future provision is an understanding of the use pattern of the facilities. It shall also look at improvement of theatre design.

1.4 Goals and Objectives

The multi-purpose nature of the complex shall define its priority along the goals and objectives line. These are:

a. To design an auditorium with an adequate capacity providing all the necessary facilities to take care of the recreational and educational need of both students and staff population, as well as other members of the neighbouring community.

b. To investigate into the aesthetics usage of cable structure as a roof system.

c. To see how form configuration could increase the acoustic performance of the auditorium.

d. To see how various design parameters are used in achieving flexibility in the planning of the spaces.

e. To see the integration of spatial functions on site with a view of achieving harmony.

f. To determine the response of user and the psychology of form in relation with the built environment.

g. To create an effective means of separating vehicular as well as pedestrians circulation within the complex.

1.5 Scope

The scope and limitation of the project shall be based on the inclusion of those facilities economically thought of as being viable. This include the auditorium, performing area, shopping, public facilities, conference and administration.

The intricate roofing problem of the auditorium shall be solved through a research into the use of cable structures. This research through a sequential order shall highlight various design parameters in the planning and design of an efficient tensile structure with the available technology to the space. An appropriate detail shall be evolved to solve the structural problem of various components of the cable structure. This research shall serve as a documentation for architecture students and others interested in the use of "space structure technology." The architects have always been at the forefront

of details evolvement while the engineer assists in the realisation of the details.

1.6 Conclusion

The planning component of the spaces shall be well co-ordinated to avoid any lapses. Also the architect shall see the level of clarity in the detail of the tensile technology used as the roofing system. The contribution of this project shall be the limit to which these basic problems are solved.

1.7 Research Methodology

In this approach the sequence and manner by which the research is carried out and the expected outcome was devised. This can be said to be the tactical method of the realisation of goals and objectives of the project at hand.

Principally it is aimed at testing hypothesis, concepts with a view of validating them, it gives an insight into problem solution and reduce time wasting.

1.8 Method Of The Research

The research employs methods such as studying the campus facilities, their performance, maintenance etc. Observation and interview techniques were used to sample opinions.

1.9 Literature Review

Published articles concerning the area of research were consulted such as Ahmadu Bello University master plan, periodicals, magazines, textbooks, microfilm, thesis etc.

1.10 Field Data

Visits were made to the existing recreational facilities to study their conditions and make recommendations.

1.11 Data Analysis

After collecting these data, analysis of these data were made to direct the researcher extract those valuable information relevant to reinforce his hypothesis. The problem of time constraints was encountered through laborous sorting of data relavent use value.

1.12 Conclusion

It is only by careful judgement and understanding of project needs that a comprehensive scheme of the project would be concluded. It is reminded that researchers should try to define their problem boundary so that adequate judgement will be made within this boundary.

CHAPTER TWO

2.0 HISTORICAL DEVELOPMENT OF THEATRE

2.1 Preamble

The formation of theatre started with the artists impression for the need of space, This conscious search gave way for this development through project development. Part of the requirement of a flourishing theatre is finance built through patronage. This high patronage has led designers, artists and team of experts to develop an elaborate materials and construction for interior and exterior finishes. In a situation where survival is the only means through which energy is conserved, then the whole system should be overhauled to meet the changing demand requirements.

2.2 Development of Theatre, The Greek Experience

Explanation has only suffice to reveal the early beginning of theatre construction based on some space utilization not on its origin. The archeologist have tried to give explanation based on the primitive culture of man, through religious rituals, story telling etc. Greece and not Egypt was chosen to be the ealiest region where theatre activities started due to Greece ealier religious observance, which superceded the discovery of Egypt in the art of ritual activities.

Space utilisation started when a search was made to see how space could be provided for the celebration of a festival in honour of Dionysus, the god of wine and fertility in 13th B.C from Asia minor. The culmination of this space

gave birth to new activities in the festival such as dances, dirthyramb and ecstatic hymn in honouring the god.

The first record of theatre activity was found in Greece, a theatre designed for Dionysus, submerged in the slope of the acropolis above the temple of Dionysus. The feature of the theatre is a semi-circular concept developed to suite the need of the audience. The amphi-theatre form of the theatre has its semicircular acting area protruding into the audience seating zone. This early development served as a source of inspiration for the development of theatres with a modern idiom.

The conquering of Greece by the Romans concentrated the development of theatre activities in their hands because of the delight found in them. The first record of a permanent theatre came up in the Pompeii city of Rome in 750 B.C. This development shows how the Romans conceived their spaces based on their aristocratic system of government.

Greco-Roman theatre form emerged when the Roman adopted some concepts of the Greek giving out a new synthesis of space conception.

2.3 The Collapses of Rome

The invicibility of Roman empire in Europe spread theatre activities to other parts of the world where elegance was admired. This theatrical regional concept development gave room for searches into more local theatres, thus,

economic activities was geared towards the retension of these civic buildings through investment.

The political and eonomic collapse of Roman empire gave way for the destruction of these civic buildings because of the unavailability of fund to maintain them. There was a gradual drift of theatre attendance after the collapse and slum in economic activities of the Romans. Rubbles of the collapsed theatres were used in other form of construction i.e the columns went to churches, marble burnt to lime to make mortar, stone blocks went into walls and forts were sunk into the earth. Those theatres that survived were used for meetings, religious gathering and theatrical activities on a smaller scale.

As learning activities increase in the field of classical literature and drama, the revival of theatre was sought to see the limit of space provision for such activities. Different types of theatres started emerging as recourse for these needs.

2.4 Origin of Modern Theatre Design in Late Renaissance

Prominent avant garde architects took up the remains of Roman theatre designs and metamorphosed it into a modern concept. Included amongst the architects were Sabastino Serlio, Andrea Palladio, Vincerzo, Scamozzi etc. They evolved four types of theatre architecture:

a. Public theatre style originating from the middle ages.
b. A style more or less generated from early renaissance pre-occupation with terrain and plateau revival.

c. Theatre designed for revivals and construction of antique tragedies and their immitations.

d. Festival theatres designed for mounting spectacles upon the occasion of a royal alliance of a civic entry.

This early movement of constructivism gave birth to styles in theatre designs. The new concepts adopted paradigm technological inovations as styles.

African Theatre

Africans could not be said to have built a formal play house called the "theatre" for performance but rather have open spaces. A thorough inquisition into this subject matter would be made to discuss the origin and nature of African theatre.

2.5 Basic Form

Looking into historical legend of African culture through folklore, myths, stories etc., one could derive an expression of negroidal theatre form. This take the cultural symbolism associated with some religions, rites etc. The organisation of these legends give Africa its true theatrical concept.

The change of African values is found through culture contact, which has an associative value of assimilation. These values could be in terms of cultural norms, rites, religion etc, which create a new direction in the perception of spaces as it suppose to express. This space adulteration due to culture contact, although has an impact, but does not

change the values of the rich traditional African theatre. Because of this rich nature, hardly can cultural dances not occur in a set up community within a period. This could be in form of remembrance of a hero or marriage, death, disaster, victory etc. which has become the consonant of interaction within an average community.

Because of this cultural alienation, the Africans have exhibited to the world that their culture is dynamic looking at its area of dominance. It has become a way of life for an African to respond whenever called upon to perform a ritual obligation to suspend all activities detrimental to the call.

Modern African theatre has taken a new direction from the traditional festival drama to a literary one through the contribution of its playwriters. The translation of beliefs, myth and other form of legend associated with African theatre by these writers has put Africans in the field of modern theatrical concept.

2.6 Theatre In Nigeria

As it has been observed that the development of theatre activities within an African context will bring a great pride to Nigeria looking at its rich tribal cultures. A pioneering artist in this field of indigenous theatre is Hubert Ogunde looking at his numerous contribution in the cause of projecting Africa's image to the outside world. Many groups that emerged within Nigerian cultural display have shown one form or the other in the display and arrangement of their plays.

These plays take place in form of motion drama performed in streets, squares, palaces, houses etc during the coronation of a king or victory in a war. One of the characteristics of these plays is the intimacy created between the actors and thd audience, since the only physical barrier in the theatre were the audience themselves. This relationship tries to show the metamorphose nature of African theatres. Examples could be Yoruba Alarinjo, the Kwagh-hiv theatre, Borno Puppet shows, the Hausa comical art of Yankanmaci etc.

The African literary drama is another form of drama with the sole aim of educating and raising the level of the people's awareness towards the ruling class through a caricature depiction of the ruling class.

2.7 Characteristics Of Nigerian Theatre

1. The feature of Nigerian drama is the blend of music and dances hyphanating an occasion. This is done in form of acrobats, gymnastic etc.
2. The stage is (or performing ground) treated in symbolic solemnity than a physical reality.
3. The relationship of the actor and the environment is of great value since they are normally secluded most often at times during festival theatre signifying some ritual beliefs.
4. The nature of African theatre with its fluid pattern has no audience visual limitation. Although crowding does not create barrier parsee, it does enhance commorative mode of that occasion.

5. Cultural differences within Nigeria geographical enclave has created different interpretative form of theatre performance, thereby emphasising these cultural differences Type of play, length of performance and audience participants are the parametric determinants of these differences.

6. Some festivals may be dramatic in themselves but not a drama showing the level of exposition to audience endurance This form of play could be found in Fulani soro dance.

2.8 Types Of Nigerian Theatrical Performance

2.8.1 Rituals

This is the dance drama performed during sacred religious and cult observances.

2.8.2 Masquerade

In this performance the artist is in form of masquerade with a mask to perform and grace the occasion.

2.8.3 Ceremonials

These traditional dances are performed during occasions like marriage, chieftaincy, birthday, naming ceremony etc.

2.8.4 War

These performances take place before or after a war battle signifying victory. Mock combats or pantomine rituals are staged to depict their enemies in a caricature form.

2.8.5 Acrobatics

Body agility is displayed through gymnastic performance, or dance performance.

2.8.6 Vocational

A traditional performance having its background from a certain profession, it is done by immitation and mocry.

2.8.7 Social entertainment

Traditional dances for pleasure, revealing joy, good news etc. musical bands are invited to grace the occasion by praising the guest and the audience.

2.8.8 Maidens dances

Traditional dances performed by young girls at the premarital stage as an expression of beauty and innocence.

2.8.9 Puppet theatre

Traditional show using puppets, dramatising folk tales of a particular society.

2.9 Nigerian Theatre Prospects

As rightly observed that for an institution to start growing there must be an injection of finance which reflects on the level of its development. So to say, the problem of Nigerian theatre is that of growth steeming from patronisation. Most of the projects shall become desolate if not protected

with adequate funds. Or they shall turn out to be "white elephant projects" It is in this light that production industries should devise means of raising the level of awareness of the public play acceptance through various ways.

The following ways are therefore suggested as a measure to keep the theatre industry at a profit:

a. Government should discourage the importation and play of foreign films in our media houses to avoid drift from the indigenous ones.

b. Government should try and create awareness through its cultural department by employing Nigerians capable of injecting radical ideas into the scenery.

c. The University theatre, state cultural organ and other professionals should be encouraged to see that research related to development is sought to reinforce the image of the country abroad.

d. Playwrites should be given the opportunity to develop their plays and research through fund allocation to research units of the university system.

e. Library for research documentation and development should be built to foster the development of a peaceful theatrical atmosphere.

2.10 Proposal For Action On The Nigerian Theatrical Scene

Boyo (1980) in his observation and experience of Nigerian theatrical scene came up with a proposal for action. This proposal if carefully studied shall induce the new blood

of theatrical acceptance and development. He outlined the proposals as follows:

a. That burden of theatre development must rest on the audience and those policy makers in the industry.

b. An investigation into various setbacks should explain the cause of poor attitude towards performance and its accessibility to the public.

c. Research into the behavioural aspect should be carried out to identify these basic factors affecting their needs.

d. National theatre and national youth centre should be established to co-ordinate the activities of various theatre institutions in the country, so that any disparity inherent in programmes would be normalised.

e. Introduction of pilot projects in the secondary level of education to teach how to collect data, impact theory in the field of theatre advocacy.

f. Creation of an environment where professional artists could meet and exchange ideas in the field.

2.11 Theatre Architecture In Nigeria

It could be emphatically stated that theatre architecture of Nigerian origin is non-existence looking at the various attempts made by designers in this direction. One of the problems of this development is that designers often neglect applying those African elements that could enrich the theatre houses. Or at times do not have a clear picture of what theatre

should be in a regional character. This line of drawback has become the poser for the new generation of Nigerian architects in exploiting the regional blend of their designs by neglecting those exhortic foreign tastes.

2.12 The Theatre Concept, Hybrid Approach

A look into the historical development of construction spaces would reveal to a great extent how spaces are defined within the context of need. Both, the Greeks and the Romans who are regarded as the pioneers of theatre architecture defined their spaces by evolving various forms of theatres to house their religious and social activities. Their conception of spaces based on many factors such as climatic, economy and material availability has shown how space intricacies could be resolved by applying various design parameters as factor.

The Nigerian theatre space could be conceived based on the nature of activities it would house, at this point space standards could be evolved to help define those audience/actors contigious activities looking at regional theatre play development. The architect with a vast material knowledge at his disposal should ensure that these materials are judiciously used if any meaningful contribution would be made in this field of development.

A hybrid concept of space utilization could be evolved looking at the advancement of theatre construction in the west with a view of incorporating those elements regarded as regional into such architecture.

CHAPTER THREE

DESIGN PARAMETER

3.0 Brief

There are various requirements governing the design of theatres for various needs. The fundamental requirement that must be met is the balance between maximum seating capacity, good vision, acoustic and structural stability. So for various performances the need for adjustment forms the basis for a good design, it must be remembered that standard planning regulations must be met as regard sitting and location.

3.1 Sight Line

The seating arrangement of the auditorium must be so designed that it meets the requirement for good sight line position. The uniform change of eye level permits good vision from seat to seat in a given row. The seating position could be staggered at times as the design requires to for vision from row to row through the shoulder.

Accurate viewing curve could be determined either by analytical or graphical method for the eye sight distribution from seat to seat (See fig. 3:1).

3.1.1 Graphical method

The diagram in fig. 3:1 shows the increment factor of the sight line from row to row from a reference point P which form the visual focus of every seat. The visual factor (C) is added to every seat to its sight line.

The disadvantage of this method is its tediousness in projection of the sight line factor from row to row to the last seat.

3.1.2 Analytical method

The individual height factor is determined using the mathematical formulae. (See fig.)

Height above stage (Y)

$$Y = \frac{c}{d}\ 2.37gx\ \frac{x}{a} + \left(\frac{b+c}{a}\right) x - c$$

Sweeping of viewing curve

$$\frac{dy}{dx} = \frac{c}{d}\ (1 + 2.31g\ \frac{x}{a}) + \left(\frac{b+c}{a}\right.$$

Change of eye level

$$c = \frac{y - \frac{bx}{a}}{\frac{x}{d}\ 2.31g\ \frac{x}{a} + \frac{x}{a} - 1}$$

a ---- distance of P from row eye level

b ---- height difference between stage floor level and from eye level 150-200 mm

d ---- rows c/c: 800-900 mm

x,y ---any eye level factor related to reference point (P) as zero system.

eye level height above floor level: 1150-1200.

3.2 Seating

Seating arrangement in an auditorium is governed by many factors which are termed as working constituents for a good auditorium design. These factors are capacity, arrangement, depth, and stage audience relationship. For a good design the seating arrangement must be such that sight line defect does not occur, invariably the architect works between various parameters in other to achieve a balance.

The visual limit is found to vary for various performances where expression of certain kind is expected to be conveyed to audience such as in drama. While in other events where this is not likely to be emphasised, the limit could go beyond 30m. The sight defect control in theatre has become the basic thing the designer must resolve for effective performance.

3.3 Acoustic Limit

In acoustic design of an auditorium, the intelligibility of the propagated sound from the stage to the audience is of utmost importance. It tries to show how sound could be distributed uniformly without any distortion, excessive reverberation, echo etc. to the audience. The elemental component of the auditorium interior such as seats, walls, ceiling, finishes, form and audience are seen in contiguity with good room acoustic.

The acoustic phenomenom such as reverberation as observed is dependent on two main factors, the amount of reflected and

absorbed sound by the surface of the auditorium, the volume and the stage area. The interior could be aided by the design of various reflecting and absorbing materials which function under different performances.

3.4 Acoustical Design Consideration

Basic approach

Auditorium acoustics have always been the deterministic factor considered in the selection of form by designers looking at the complex nature of the activities it would house. So an element of balance is sought for the homogenous requirement, such as aesthetics, technical, functional, artistic and economy looking at the change in form and nature of theatrical activities.

Other elemental factors considered in the intelligibility are, seats types, walls, shape, volume, ceiling heights etc. These elemental acoustic design considered have become non exhaustive and have created the avenue for some.

For a good acoustic determinism, the following factors were considered by the designer:

i. Distribution of sound within the interior, so that farthest seats are highly intelligible.

ii. Diffused sound energy should be uniformly distributed.

iii Reverberation within the auditorium should be kept at a minimum.

iv Defects such as echoes, long delayed reflection, flutter echoes, sound concentrations, distortion, sound shadow and resonance should be eliminated.

v. Vibration and noise should be reduced for good audience attention.

3.4.1 Loudness level

The following critaria were used as governing factor for good a loudness level:

a. The form selected should be such that the audience are brought close to the sound source.

b. For a good sound feedback the sound source should be raised.

c. The audience level should be raked so that deflection of sound do not create distortion.

d. Where necessary sound reflecting surfaces should be used as aids to acoustic performance (such as plaster, plywood, rigid plastic board).

3.4.2 Sound diffusion

In sound diffusion, the basic variant of diffusion should be selected, this include the structural elements, coffered ceilings, serrected enclosures, sculptured surfaces etc. The architect within the level of the available resources would select the best approach to his interior acoustic.

3.4.3 Reverberation control

To reduce reverberation the auditorium sound absorbing materials should be carefully selected and placed. This would go along way in reducing defects such as echoes, flutter echoes, long delayed reflection and sound concentration. Emphasis should be placed first on the side walls which have high diffusion problem. The shape of the rear wall will be a key determinant in the material selection.

3.5 Reverberation

Reverberation is the prolongation of sound as a result of successive reflection in an enclosed space after the sound source of the sound has been turned off.

The reverberation time (RT) is the time for the sound pressure level in a room to decrease 60 dB after the sound is stopped.

For good auditorium acoustic the reverberation time should be controlled by the interior finishing knowing fully well the function of the auditorium.

The reverberation time varies for different production in a multi-functional auditorium, the time should be between 1.5 - 2.0 second for music and about 1 second for speech. The relationship between reverberation time (RT), surface area and the volume of the room is given by the capital Sabin equation:

$$RT = \frac{0.16\ V}{A + XV}$$

where RT = reverberation time

V = volume of room in cubic metre

A = Total absorption in sq. m sabin.

X = Air absorption coefficient.

3.4.4 RT and room flexibility

The concept of room flexibility is to see how the reverberation time of a particular production could be used for another taking into account the multi-functional usage of the auditorium. This shall be succintly shown below:

a. A music room designed for a reverberation time of 2 seconds could be adjusted for an RT of . second for speech. To achieve this requirement ceiling baffles are reduced by adjusting to reduce the auditorium volume. Or panels could be used covered with soft materials of high absorptive value.

b. For balance usage between music and drama, the room could be designed with the reverberation time of drama. For the music RT requirement, electronic extension devices are used to extend the reverberation time.

3.5 Room Acoustical Defects

3.5.1 Echo

Echo occurs if a minimum interval of 1/25 seconds (for speech) to 1/10 (for music) elapse between the perception of the direct sound reflecting sound originating from the source.

3.5.2 Long delayed reflection

In delayed reflection the time lag between successive reflections and perception is quite less compared to the echo timing.

3.5.3 Flutter echo

Flutter echo consists of rapid succession of noticeable small echoes, produced between parallel sound reflecting surfaces. A good treatment of the roof would absorb this defect.

3.5.4 Sound concentration

Concentration of sound is caused mainly by concave surfaces. The sound upon reflection converges at the focal point of the surface placed somewhere within the interior. Convex surface absorber should be used where appropriate to correct this defect.

3.5.5 Sound shadow

This defect phenomenom is noticeable under a balcony which protrudes too far in the air space of an auditorium. To reduce this defect the balcony's department should not be more than twice the balcony's headroom.

3.6 Sound Amplification

Sound amplification devices are aids provided in a large auditorium in form of electronic microphones. Their basic function is:

a. to reinforce sound level;

b. to minimize room reverberation;

c. to provide amplified sound for dead rooms;

d. to reduce the masking effect of a background noise.

3.7 Amphitheatre Acoustics

The consideration of acoustic design both for outdoor and indoor performances had made designers to devise means of increasing intelligibility to its manimum requirement. The problem associated with outdoor space is that of airborne noise generated from external sources such as automobiles, pedestrians, wind etc. This problem if not well tackled in the functional zoning of the outdoor space would generate into desolate structure usage. So as a measure, the basic requirement of the outdoor space for recreational activities should compromise between these defects and the structures placement.

As it has been observed that outdoor acou stic is generally poor due to the following factors:

a. The loss of energy of sound source as it moves from the point source outward.

b. The impedance created along the sound path through audience absorption.

c. External noise generated from various sources.

To correct these defects in acoustical performances, various forms of amphitheatre were evolved by the earliest Roman-Greek actors through the sighting of their amphitheatre far away from the town and also by locating such structure in a natural slopy area to the advantage of the planning concept.

As a measure to reduce these defects, amphitheatre's site should be selected based on proper zoning or planting concepts to reduce direct sound penetration. Embarkment of the natural site could be employed by either elevating the noise source or submerging the source. This would give a considerable measure in initial cost through the provision of masking system in form of electro acoustic system.

The following measures should be considered in open air theatrical acoustical performance:

a. The miximum distance of seats should be kept at a reasonable depth.

b. The sound should be aided with acoustical reflecting surfaces.

c. The seating areas should be raked such that the chosen angle does not impede sound path.

d. Reflecting surfaces on the existing building should be carefully checked to avoid echoes, etc.

3.7.1 Sound amplification

Much as the designer is trying to provide good acoustical design of an auditorium through various considerations, it has become obvious that natural acoustical requirement can not be met in some auditoria due to their volume (capacity), thus an acoustical aid in form of electro-acoustic system is incorporated into the system. This aid is not seen as an end in itself, but rather, as a measure to reduce complex acoustical performance of the auditorium.

This system should try as much as possible to reduce echo, long delayed reflection, reverberation by studying the room characteristic. Time interval between direct and amplified sound should not exceed 1/50 second.

In general the incorporation of an electro-acoustic amplification devise is to:

a. Reinforce the sound level from the point source to the audience taking note of th auditorium pressure level.

b. Minimise room reverberation, this can be achieved by knowing the volume and the attenuation of sound source.

c. Provide artificial reverberation rooms for that have very low reverberation time.

d. Reduce masking problem associated with an excessive background noise.

3.8 Acoustical Materials

The complex nature of an auditorium has necessitated the need to provide various forms of acoustical aid for a good performance of the interior, one of the requirement is the provision of absorbing and reflecting materials in form of panels. These materials are located at various points within the room to generate the much needed acoustical performance of the auditorium.

The nature of the side walls has demanded the need to provide absorbing panels in order to reduce defects of multiple reflection within the interior. The rear wall and the ceiling systems are encouraged to utilized reflecting panels for a good room intelligibility.

There are 3 types of acoustical materials commercially in use:

i. Prefabricated units

This include acoustical tile which is the principal type of material available for acoustical treatment; mechanically perforated units backed with absorbent sheet.

ii. Acoustical plaster and sprayed on materials

These materials comprise plastic and porous materials applied with a trowels; and fibrous materials combined with binder agents, which are applied (sprayed on) with an air gun or blower.

iii. Acoustical blanket

Blankets are made up chiefly of mineral or wool, glass fibres, kapok batts and heirfelt.

3.9 Auditorium Morphology

Looking at historical past, from Greeks to Romans when auditorium took circular, semi circular, hemispherical and other geometric form, this came due to development necessitated by need and taste. This form metamorphosis has derided itself into modern day requirement for theatrical plays which is termed innovation. Even with these changes into modern idiom, the search for form still takes design formation into historicism. This pattern has become a form of borrowing to blend into the post-modern era, to this end, various descriptive terms are used to refer to these forms such as open stage, proscenium, arena etc.

A look into these vivid descriptive terms below would show this metamorphosis.

3.9.1 Zero encirclement

(Proscenium stage, picture frame stage and end stage) (See fig. 3:1a).

AUDITORIUM MORPHOLOGY

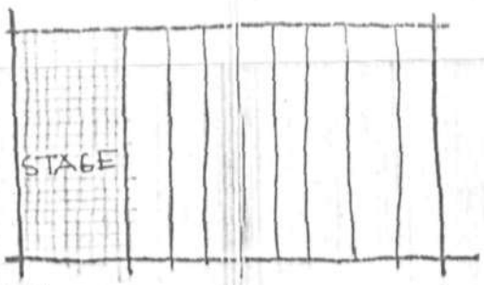
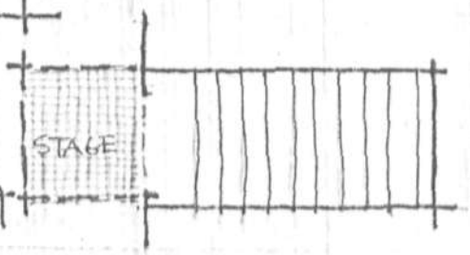


FIG 3:1a



Zero degree encirclement

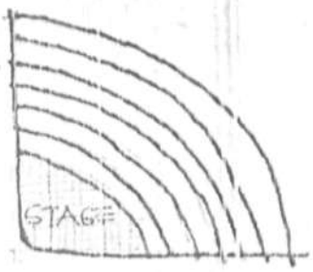


FIG 3:2a

90° encirclement

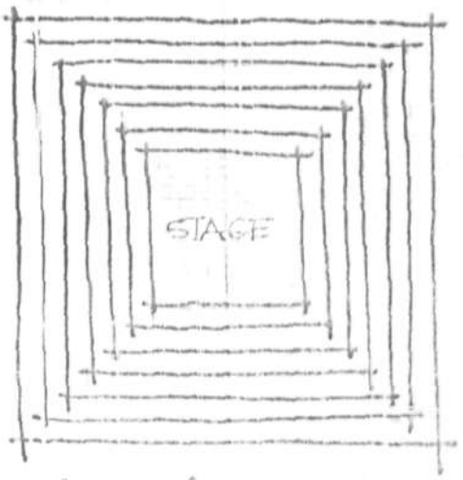
FIG 3:3a



210 encirclement



FIG 3:4a



360 encirclement

Features

*The angle of audience spread in front of masking frame is determined by the maximum size of the corners cut off from a rectangularly shaped performing area that can be tolerated by seats at the side.

*Audience may not fill angle of encounter from point command.

*Audience farthest from performing area.

*Large range in choice of size of performing area.

*Provision for a large amount of scenic wall surfaces without masking sight lines.

*Horizontal movement of scenety typically made in both perpendicular and parallel to centre line.

*Possibility of short differences in arrival time between direct and reflected sound at the spectators.

3.9.2 90° to 130° encirclement

(Pictorial open stage, wide fan, hybrid, thrust stage) (See fig. 3:2).

Features

*Audience spread defined and limited by angle of encounter from point of command.

*Performing area shape trapezoidal, rhombic or circular.

*Audience closer to performing area than with zero encirclement.

*Audience picture frame less dominant.

*Provision of an amount of scenic wall surfaces possible without obscuring the performing area.

*Horizontal movement of scenery is possible in directions at 45^{o} to and parallel to centre line.

*Shape of seating area places maximum number of seats within the directional limits of the sound of the unaided voice, beneficial for speech performance.

3.9.4 360 encirclement

Arena stage, theatre in the round, island stage, centre stage) (See fig. 3:4d).

Features

*Simultaneous eye contact between performer and all spectators not possible.

*Audience closest to performance.

*No range of choice in size of performing area.

*No scenic wall surfaces possible without obscurring the ve view of the performing area.

*Horizontal movement of scenery not readily possible.

*Enciclement by audience demands actors vomitory entrance through audience area.

CHAPTER FOUR

RECREATIONAL ASSESSMENT

4.1 Preamble

The prevailing problem of need and time has necessitated planners to understand salient problems which might be of great need to their projects execution as required. This assessment when carefully planned within the available local resources would give an insight into search for new ideas in the generation of complex thoughts to tackle complex problems.

To this end, a look into various factors affecting response to recreational demand within the project need is therefore put forward as a guide to the survey of existing facilities against the background of providing new ones.

With these available tools, errors shall be eliminated knowing the basic determinant of the project need, thus new concepts would suffice along the project execution after a careful consideration of various defects.

4.2 Assessment of Recreational Demand

Within the demand requirement, recreation can be defined within the context of time and choice looking at the freedom associated with activities.

In order to highlight the leisure demand rate per unit space time of a community, a model system is used to look at:

a. the classification of the kinds of constraints which exist upon the use of leisure time;

b. measurement of their relative effects;

c. the utilisation rate of the facilities provided and to see their inadequacy within the time space.

4.2.1 Model approach

In this method and understanding of the use of pattern of the facilities provided within the recreation demand is assessed in order to give a clear picture of their deficiencies to meet the local demand requirements. It also looks at space adjacencies in order to understand the user constraints. The monitory system within the model planning will generate an awareness for the users in terms of utilization.

4.2.2 Concept and measurement adopted in a model

A measurement model is based on a hypothesis that all leisure behaviour is in response to a series of constraints which can be isolated or aggregated and quantified and to an element of choice which can be predicted in terms of probability.

4.2.3 Concept of constraint

As rightly agued that leisure cannot be constrained by choice of participation but rather by activity rate measured in terms of leisure performance. This tries to show that only through leisure performance that constraints could be determined.

Two types of constraints are identified within this study:

a. Structural or personal constraint: This looks at the time available, discretionary income, the characteristic of the population such as age, sex and their educational background etc.

b. Environmental constraint: This constraint is divided into facility constraint (deferred demand of facilities looking at their economic feasibility) and linkage constraint, which looks at the proximity of facilities within the user demand.

4.2.4 Concept of demand

The concept of demand as conceived by Frost (1971) that, it is only through the pursuance of those activities expressed in the facilities that demand could be measured. The definition within this context would look at spacing of time for a particular population for the use of their leisure time, this include time spent on recreation referred to as manifest demand, and latent demand due to constraint in participation.

Latent demand could be categorized into three ways, personal deferred demand, facilities deferred demand and linkage deferred demand due to environmental constraints.

4.3 Concept of Recreation Preference And Choice

As viewed by (Ian) that it is only by setting up preference scale that an assessment of sets of constraints that satisfied the preference could be measured. The leisure time of a given community could be isolated in order to show the demand characteristic of that population, this time would then see the recreational demand as distributed on facilities provided. This measure tries to understand that even with activities isolation preference could still exist.

4.3.1 Perceived and actual constraints

The perceived environmental constraints are taken as a set of norms which are measured against an actual constrain in relation to the real or proposed provision of facilities and their relationship.

4.3.2 Measurement of recreational demand

Many approaches to the measurement of recreational demand of a community have been devised to try to understand some salient problems associated with their response to demand level. This study limit tries to understand:

a. The requirement of a given population as regards facilities provision. This form of approach has the tendencies of bias towards the existing facilities drawing negative conclusion on their utilisation.

b. The use of norm, developed on a natural or regional basis of manifest demand in situation of wide available choice. The inherent weakness of this approach is in its reliance on existing situation defined arbitrarily as wide or limited in their supply. The advantage of these norms lies in the reflection of conscious policy outside the planner's immediate control as in the case of facilities provision.

c. The environmental constraint in recreation which would help in calibrating leisure model from manifest demand about choice in relation to existing facilities.

4.3.3 Measurement of recreational supply

The measurement ratio is based on the function of facilities available, their quality and capacity for particular activities and period of opening. It is only by trying to balance up the supply and demand for recreation and weighting their constraint upon realization, that soundly based approach to problem planning for leisure could be sought.

4.3.4 Time

The major factor of leisure determinant is time. This shows the variation in the allocation of time for various recreational purposes. This time is divided and measured as mean hours of available time per year, such as time throughout the day, day of work and month of the year.

Time could be divided into two types under a specified period:

a. Essential time, this is the time committed to essential activities like sleeping, eating, primary work, schooling and travelling.

b. The highly committed time shows the grading of activities such as overtime, optional shopping and home repair. The time allotted for this activity is regarded as the leisure time.

4.3.5 Money

Money has become a great factor in the attendance of leisure activity since acquisition shows the limit to which recreation could be pursued. With increase in income the tendency towards recreational demand increases, thus facilities awareness and exposure increase as well.

4.3.6 Energy

The energy distribution of activities tries to show the relationship between various activities in term of demand requirements. Under the classification some activities are found to be highly patronised during the day time or evening and weekend. This shows that functional displacement of high energy activity would have to be considered in order to find its working variant within the same period.

4.3.7 Preference

A preference scale arises after a thorough analysis of constraint for time, income energy as discussed within the model study limit. After this study, a norm is developed as preference to those activities on the basis of data available, and judgement made to see how this population group spend their leisure time on various activities.

4.3.8 Supply

A supply survey tries to show the trend in the demand of leisure time facilities in order to detect the fault inherent in the provision of such facilities, and also be able to compare these facilities with those in existence in order to establish a pattern in the development of the deficient ones.

4.3.9 Linkages

Facilities provision for recreation would have to work in relation to the catchment area for its population so that time does not become a constraint in the attendance of these facilities. It is imperative to note that it is only by adequate provision of time lag that people would not consider the journey time as being critical.

4.3.10 Attraction

As these facilities are provided they are made to work in close relationship with certain infrastructures e.g location of a bar near a restaurant, restaurant near a

theatre. The attraction towards these facilities tend to be high looking at their functional displacement.

4.3.11 Conclusion

The model has helped in tackling constraints of recreational demand through these ways, first it has shown the constraint inherent in existing facilities or planned facilities on the population in its catchment area and obtain a clear structure of activity and their relationship. Secondly, decision taken on any planned facilities should address itself to the prevailing local demand problem.

RECREATION IN AHMADU BELLO UNIVERSITY

4.4 Existing Facilities Survey

Within the context of space utilization, the recreational facilities located within the campus were studied in order to see the deficiency of these facilities taking into account their location and economy.

In this study many questions were generated in order to understand the use pattern of the community and to see measures to be adopted in solving the problems of functional requirements. These questions, inquisitive as they are, try to look at;

a. leisure demand of the community and their need to the complex;
b. how these facilities provided can generate awareness in their usage;
c. how can the societal leisure norm be met without obstructions.

These and other questions asked within the design problem synthesis would help the designer achieve his set out objectives.

The study focus understood that the use values of these facilities was based on the following critaria:

a. Location
b. Space
c. Function
d. Form.

The summation of these values sees the need and the problem inherent in their workability on the high population demand.

a. Lacation

In the study of the physical strategy of the functions and their catchment area, it was discovered that the existing planning system of the campus never made adequate provision for good functional disposition. So the campus planning pattern which is not consistent with the present trend and demand requirement is the first deficient source. The second problem source was the functional requirement demand which is not in congruent with the local demand. So this polarity could be seen as an area of drawback in facilities utilisation.

b. Space

Much as functional requirement is discussed with space standard, it was discovered that this parity is not normally considered looking at the facilities provided within the 80s and the local demand need.

c & d. Form and function

Need has transceded form as it has been studied, looking at various facilities and their architectural expression. It could be seen that economy which might have been considered was not truly playing with sight harmony as means of visual vibration. Thus, the architecture of these facilities if well studied would

tackle the site and form configuration of the building parsee.

4.4.1 Facilities and their location

It has been brought into light that the thesis in discuss is within the context of recreational facilities since majority of its users shall be students, staff and some members of the public, it is therefore viewed that the study of the existing facilities as they were, would create a format for the design to tackle the problem of under-utilization and also generate awareness through the use of local resources.

Facilities

The distributive tendency of the facilities amongst its various users shows lapse in the ratio of sport recreation and social recreation. This ratio 8 to 2, sports and social has shown that alienation is bound to exist amongst its teeming users.

To understand the alienation factor Ukwedeh (1983), observed that the use pattern of these facilities was in ratio 1 to 5, sports and social recreation respectively. He asserted further that where these facilities are provided, usage is only for registered members. This form of restriction has further increase the users agony.

In a situation where facilities are deficient and restriction placed on their use, mental stress is bound to suffice out of duress exasperation.

The social recreational facilities with high demand but deficient in provision should be provided. The restriction system of utilization placed on some sporting facilities should not be allowed in the use of the social facilities.

These facilities with high demands as surveyed by "Ukwedeh" are used for:

a. Conferences.
b. Symposia.
c. Dances.
d. Drama.
e. Concert.
f. Film shows.

Sport recreational facilities	No
Basket ball court	3
Football	1
Lawn tennis	5
Swimming pool	1
Table tennis	1
Badminton	1
Cricket	1

Social recreational facilities

Drama village

Assembly hall

FIG 4:1

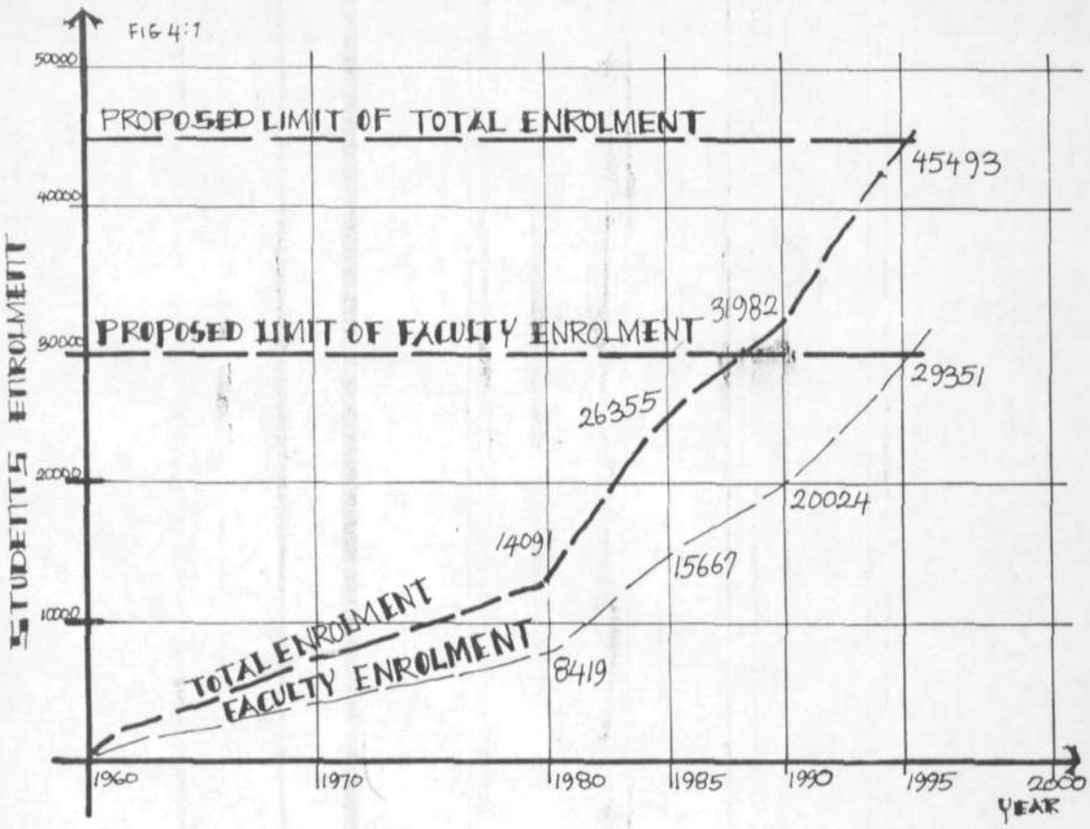
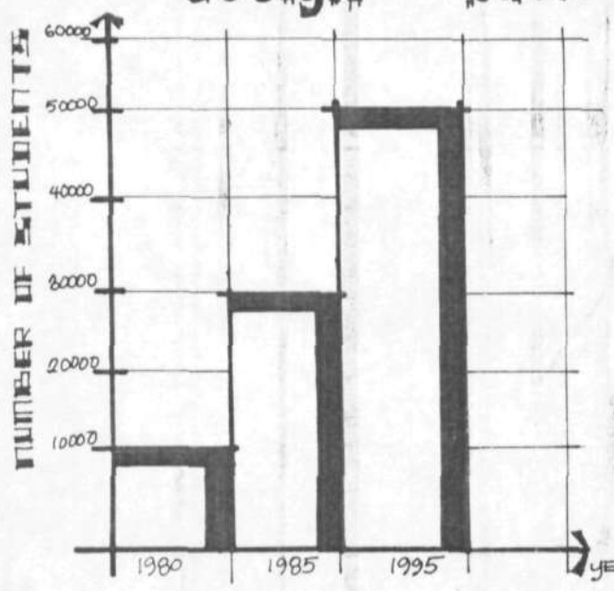
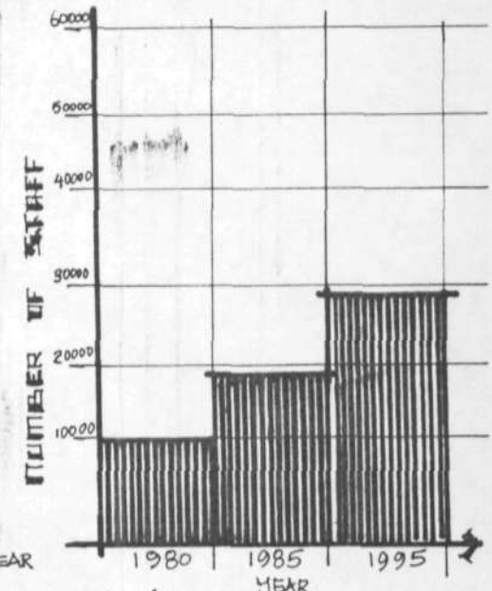


FIG 4:2



design basis

FIG 4:3



SOURCE : A·B·U· MASTER PLAN SURVEY 1981

Assessment of the social facilities

The assembly hall and the Drama village which were supposed to serve these intricate requirements are found to be below capacity (Assembly hall, 500, Drama village, 100) or lack facilities. So parties, social engagements, Drama, concerts etc. are taken to hired places by the students and staff organisers thus, creating a vital vacuum supposed to be filled by development.

The basic problem as it can be seen from the earlier discussion is on the distribution of these facilities as against their catchment areas and the lack of those facilities necessary for their patronisation. The designer as a reminder shall look at space as they were against the background of space as they should, in order to create utilisation harmony.

4.5 Population Survey And Catchment Area

As part of the requirement for population survey for the thesis in focus, relevant data were used to substantiate the existing ones in order to provide adequate facilities needed. The complex with its multi-functional activities is to serve the needs of both students and staff as well as the neighbouring communities in providing cultural, educational as well as the recreational need of the population.

The survey shall look at staff and students population, facilities both within the main campus and the new campus area, number of conferences (national and regional) number of clubs and associations, drama, concerts, film show etc.

A critical analysis of these data shall highlight the functional scope and limitation of the project.

4.6 Demographical Data

Fig. 4:1: 1980-81 Population Survey

CAMPUS	NO OF STUDENTS	%	STAFF	%	TOTAL	% OF TOTAL
SAMARU	8,383	70.33	8,925	77.41	18,583	75.19
ADMINIS-TRATION	2,101	18.15	1,284	11.14	3,445	13.94
ATC ZARIA	1.201	10.05	720	6.25	1,921	7.77
OLD TEACHING HOSPITAL	167	1.40	600	5.20	767	3.10
TOTAL	11,912	10	11,529	10	24,716	100

The above data tries to show the spread of students and staff population of Ahmadu Bello University from 1980 - 81 period. It could be observed that main campus Samaru has the highest staff/students strength which tends to reinforce the capability and desire to accommodate those population required to patronise the auditorium complex.

TABLE 4:2 STUDENTS, STAFF RATIO FOR 1985

CAMPUS	STUDENT	%	SENIOR ACADEMIC STAFF	%	STAFF ADMINISTRAT. SENIOR	%	SENIOR TECHNICAL STAFF	%	I & J STAFF	%	TOTAL	%
SAMARU	19065	63·86	2031	76·09	244	82·05	310	96·27	12239	80·95	83,887	70·22
ADMIN	3914	13·11	239	8·95	41	13·80	—	—	1457	9·64	5,651	11,71
OTHER CAMPUSES	6876	23·03	399	14·96	12	4·05	12	3·73	1427	941	8,723	18·07
TOTAL	29,855	100	2669	100	297	100	322	100	15120	100	48263	100

SOURCE: A·B·U MASTER PLAN SURVEY 1981

TABLE 4:3 STUDENTS, STAFF RATIO FOR 1995 PROJECTION

CAMPUS	STUDENT	%	SENIOR ACADEMIC STAFF	%	SENIOR ADMIN. STAFF	%	SENIOR TECHNICAL STAFF	%	I & J STAFF	%	TOTAL	%
SAMARU	36065	68·70	3515	78·42	370	8222	524	86·62	18341	83·74	58815	73·11
ADMIN	6812	12·98	410	9·15	50	11·11	—	—	1468	6·70	9240	11·49
OTHER CAMPUSES	9616	18·32	557	12·43	30	6·67	88	1438	2,094	9·56	12385	15·40
TOTAL	52,493	100	4482	100	450	100	612	100	21903	100	80,440	100

CHAPTER FIVE

CASE STUDIES

5.0 Brief

The use of case studies as design learning tool has helped in exposing designers to various problems and solutions inherent in their design formation through the knowledge of the existing situation.

The architectural case studies looks at the various precinct details as regard functions structures, site and economy with a view of identifying the intricacies inherent in them in order to find ways of incorporating or rejecting some ideas within the pursued project scope.

So as a measure towards good planning of a similar project needs, an understanding of the existing situation would reveal to a great extent the advantages derived so that new concepts shall give the much needed direction of a new design.

5.1 National Theatre, Lagos

History

The theatre was built in 1977 as a venue for the world Black Festival of Arts and Culture, by the Federal Military Government of Nigeria. It is sited in Lagos, the capital city of Nigeria and covers an area of about 22000m^2 and a height of about 31m, which shows its meganature in Lagos surburb.

5.1.1 Function

As a functional entity it is used for various activities such as debates, symposia, seminars, conferences, workshops, concerts, Drama, Dance, Film shows etc. Other facilities to take care of its multi-functional nature are provided as well.

5.1.2 Description

The theatre has four entrances leading to various halls. The VIP entrance bears the coat of arms which leads directly to the main lounge, a section of the theatre. The entrance "C" of the theatre leads directly to the artistes dressing room which has a lobby to the back stage. This entrance is used mainly by the performing artistes. The public entrances are tagged "B and D", these entrances lead into lobbies extended around the foyer. From the lobby the public can have access into the theatre from the numerous entrances decorated with Nigerian art works. Ticket offices are cited in the lobbies where tickets could be bought for shows. Recreational facilities such as bars, restaurants and lounges are provided at the foyers. The main hall was designed in such a way that it can be used for sports when demand permits. This can be done simply by eliminating the stage effects by displacing 500 seats around the auditorium. Location at Iganmu could be approached from Lagos Island through western avenue flyover while those from Lagos mainland could approach it from costain round about and entrants from Apapa would use the Idera end.

Parking

Inspite of the few parking spaces provided for "VIP" guests at the basement of the theatre with high security system, the public car park are too few and exposed to theft. The distance of the car parks from the theatre is the major problem facing the users.

Lighting

The natural lighting and ventilation could not be achieved because of the theatre's depth and the supplementary power supply is not sufficient because of its erratic supply by NEPA.

Acoustic

The most important aspect of a good designed auditorium is its ability to provide good audibility level to its audience and that has been archieved in the design by the good treatment of the walls, ceiling and seats with both reflecting and absorbing materials. These treatments reduce defects such as echo, reverberation and excessive diffusion of a propagated sound within the interior.

Structures

The canonic design form of the theatre was derived from the army cap. The theatre took its geometric form from a circular plan with a simple concrete shell roof. The structural system used is the "simple frame" system, where slanting columns were arranged at certain interval to give by fixing the side section of the stage at ground level, and

the chairs cleared by means of two lift installed in the side section of the stage box.

5.1.3 Functions

Cinema hall

There are two cinema halls in the main bowl each having a capacity of 657 seats and equipped with 35 mm and 70 mm projectors.

Conference hall

This has a seating capacity of 1200 equipped with sound equipment and a simultanious interpretation system installed to give room for participant selection of language code required.

Press centre

This is an arm of the conference centre giving press accrediction and serving the general public. It has a typing pool equipped with telex and phone services for participants during conferences, symposia, seminars etc.

Offices

For administrative purposes some offices are provided for officers and their assistants for the effective cordination of the theatre's function and its maintenance.

Reception

The foyer is the grand reception lobby where recreational facilities such as bars, snack bars, restaurant etc are located.

5.2 General Observation

Access

The theatre could be approached from various entry points around Lagos metropolis because of its central location. Its the canonic configuration arrived at. Ramp system was utilised at all the entrances to serve as drive in for audience to the first level where the admin, seminar rooms, conference room, restaurant, Bar etc. were located.

Decorations

The theatre has shown an exemplary decorations motive by the use of different kinds of African traditional murals, paintings, carving, textile, bronze and brass works within the foyer and other rooms of the auditorium complex. The decorati' ı aspect could be te med classic.

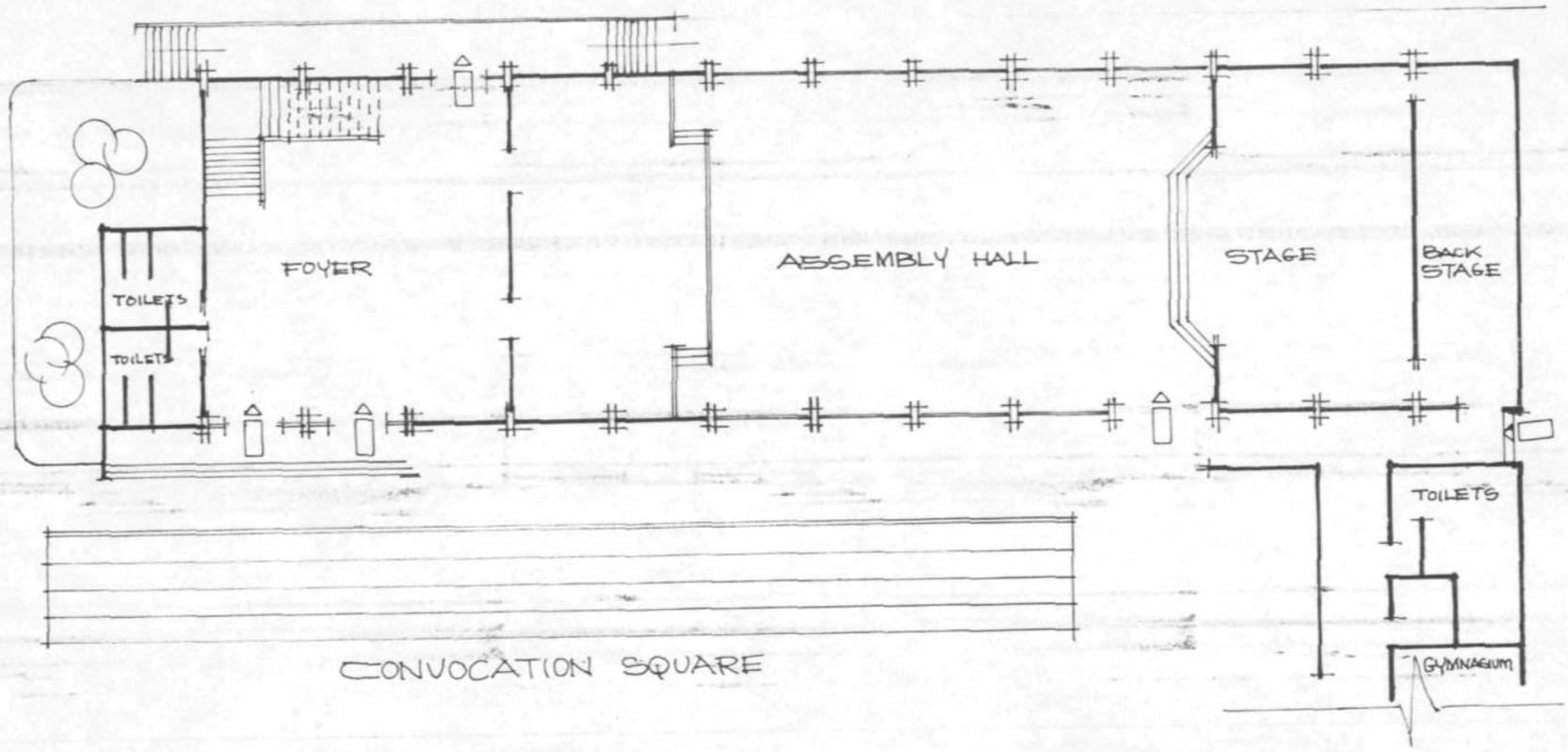
Land scape

Various land scape elements such as trees, shrubs, flowers, seating have been used to harmonise the building and its site.

5.3 An Apraisal Of A.B.U. Assembly Hall

Background

The assembly hall was built in 1960 to serve as the heart of major recreational activities such as Drama, concert, conferences, lectures, seminars etc, for the campus community and its environs. But the events of the 80s such



GROUND FLOOR PLAN

ASSEMBLY HALL A·B·U ZARIA

FIG 5:4

as growth in the number of students and staff population has necessitated the need for provision of various facilities for the wellbeing of the community at large. The hall designed for 400 audience was found to be far too inadequate for the demands of 80s and beyond, so a proposal for a multi-purpose auditorium is therefore welcomed to provide for the recreational activities demand.(FIG 5.4)

Site location

The hall is located near the central core of the university administrative unit, the senate building. It is bounded on the north by the senate building, on the east, by the convocation square and on the west by the Department of Maths. The gymnasium adjacent to it is the major noise source to the hall. Its strategic location would have been ideal if it had been designed to meet the demand of 80s and beyond.

5.3.1 Orientation

The orientation of the hall is south east along its long axis and north west along the the short axis. This orientation does not permit maximum utilization of the cool south west trade winds, and at the same time does not have sun shadding devices.

Basic division

Basically it is divided into the auditorium, foyer, stage and the changing area. The performance of the hall shall be based on the functional relationship of the units.

5.3.2 Foyer

The foyer is the main lobby of the assembly hall, this is located at the rear end of the hall's long axis. The area was designed to accommodate the large number of audience going and coming out of the auditorium. A box office for the selling of tickets for shows was not provided because of its untheatrical nature. Refreshment facilities such as bars restaurant were totally absent as well.

5.3.3 Access

There is no definite access point because of its openness at all points. But basically it could be accessed from the hostels through the convocation square passing along the gymnasium east end. It could also be accessed from the senate building through the south east end of the building.

5.3.4 Parking

There is no official parking space for the audience, but rather the open space used as the convocation ground is used instead for parking.

5.3.5 Circulation

The circulation is fairly defined around the site because the parking and the convocation dais are the major conflict zones for the users. But the internal divisions are well defined.

Fig 2:3

SECTION ELEVATION

5.3.6 Delivery

The production instruments are delivered through the back door of the stage acting area. Instruments delivered are screens, background, band instruments, lighting equipment etc.

5.3.7 Structures

The structural system used was the simple portal frame system arranged on modular spaces of the hall. Its height is about 11m, with steel purlins raised and laid across the portal frames. Galvanised aluminium roof sheets were used as the roofing materials.

5.3.8 Ventilation

Ventilation which is seen as the basic determinant of comfort is nearly lacking because the orientation of the windows do not utilise the advantage of the predominant wind direction.

5.3.9 Lighting

There is poor lighting of both the hall and the stage for performance. While the artificial lighting installed to correct the major defects were not systematically designed to take place.

5.3.10 Decoration

There is total lack of good finishes for both the interior and exterior decorations. Simple white wash was used instead.

5.3.11 Acoustic

There is high acoustic defects because no part of wall was treated against reverberation and echo.

5.3.12 Landscape

The landscape of the surrounding building is totally barren. Visual enhancement of the structure is totally lacking.

5.4 Drama Village, Ahmadu Bello University, Zaria

Background

The Ahmadu Bello University theatre studio was conceived by the English Department to create an environment where theatrical activities could be exposed to its learning students. Its conception, based on learning need has now metamorphosed into an arena for the university's recreational venue. The demand requirement of the university population was raised after the awareness much needed for acceptance in the theatrical profession was raised by the outstanding performance of the English Department in collaboration with the Department of Cultural Studies. FIG 5.5

The theatre initially designed to accommodate fifty students has expanded five folds in order to give more room for its teaming audience.

A·B·U· STUDIO THEATRE DRAMA VILLAGE

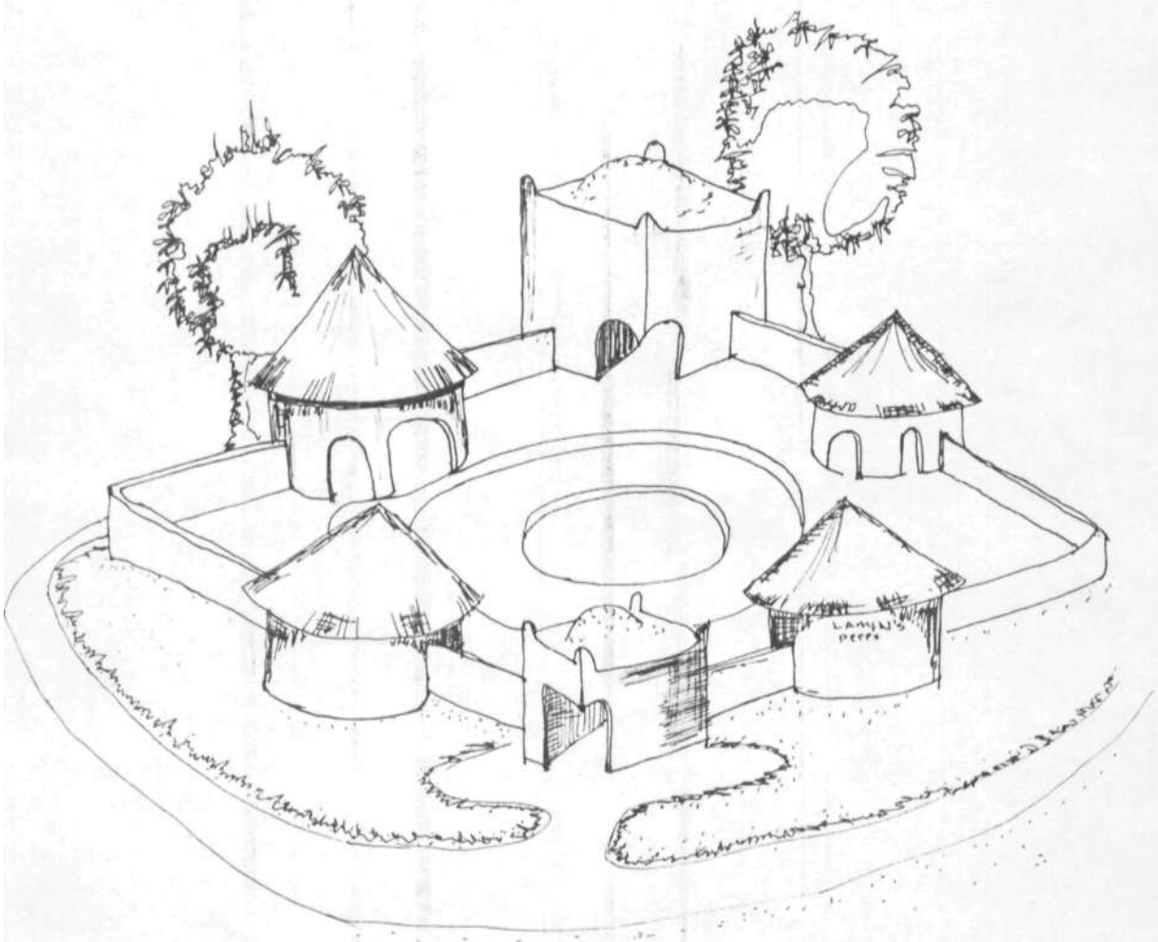


FIG 5:5 AERIAL PERSPECTIVE

5.4.1 Design concept

The concept of the planning was based on the use of traditional African symbolic form, the circle. The circular structural forms were arranged and spaced around a common open arena, (See fig. 5·6) the stage. The concept of audience participant, an African mode of theatre acts brought this form of relationship.

In most of the plays staged, the actors form part of the audience, and the audience form part of the actor. So this form of relationship creates the intimacy associated with African theatrical acts.

5.4.2 Finishes

a. Decoration: Mural decoration of African origin was used for the background stage wall and the exterior wall.

b. Floor: The normal cement sand screed finishing was used for the floor, both acting and audience zone. Looking at the functional use of the arena, the screed finishing has the disadvantage of not lasting longer. Durable hard wearing material in form of terrazo is therefore advisable to be used, this enhances the quality of the floor treatment.

c. Roof: The architect in searching for a language adopted the traditional roofing concept of thatch covering. Except for the rectangular dressing structure

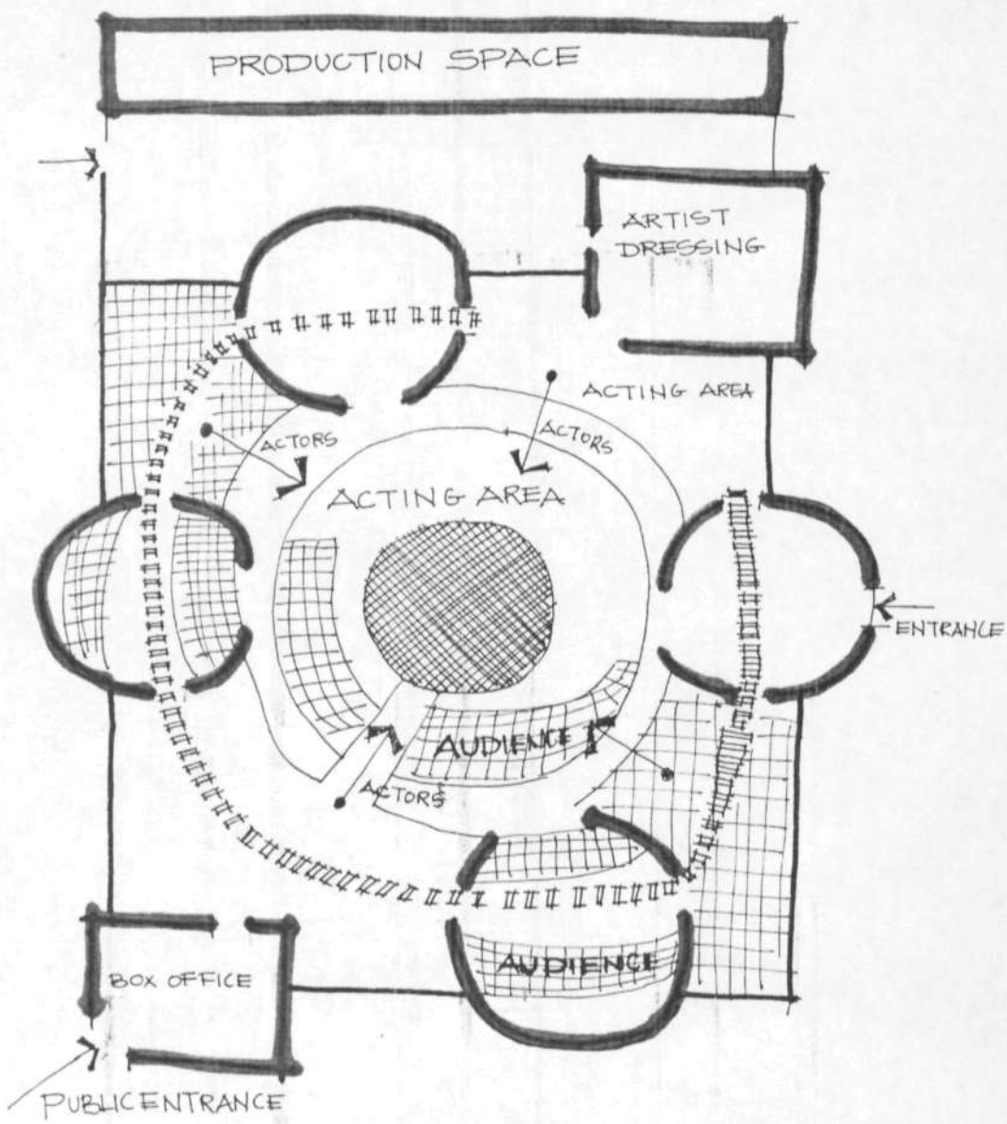


FIG 5:6 THE SPACE SYNTAX OF THE THEATRE IS BASED ON THE INTIMACY OF AFRICAN THEATRICAL ARTS. THE ACTING AREA BECOMES THE FOCUS WHILE THE AUDIENCE WHO PARTICAPATE IN SOME PLAYS REVOLVE AROUND IT

where azara flat roof construction was used, all other structures in form of circle adopted the designer's concept. Special maintenance technique to tackle the seasonal associative thatch roof problem was incorporated.

d. Walls: For a sound traditional based construction, earthen mud was used for the structural wall, and cement sand screed was used for the final finishes. To give it the African look, mural decorations featured.

5.4.3 Conclusion

The understanding of the use pattern of the theatre has given the much needed creativity by designer's to design for the people's tastes rather than looking for exhortic foreign concept.

The theatre on a smaller scale, with deficient facilities has displayed that audience need could be met if theatre awareness is raised looking at the changing pattern of the society.

CHAPTER SIX

6.0 HISTORICAL DEVELOPMENT OF TENSILE STRUCTURE

Tensile structures are structures which carry load under tensile stresses. The tensile stresses take the shape of the loading on it, thus, the loading is the major determinants of its form configuration. One of its characteristics in structural analysis is its zero stiffness factor. This tends to give it its high strength under tensile stresses.

These structures have been used right from pre-historic times when man found it difficult to access places in thick forest or jungles by walking or climbing, but instead utilized ropes which swings him from point to point in these jungles. Again shelter is the most important necessity which man has tried to solve for environmental adaptation purposes, this he does by living in caves or tent structures using animal skin as the membrane structure. For transportation purposes suspension structures in form of bridges have been used to transport animals, more people across or canal or channel to their various destinations (See fig.6.1).

Modern development

The development of this tensile concept using available technology has advanced the world into a new age. Its early modern construction is found in the area of bridge construction using steel lattice frame. These bridges are made to span large distances between 50 - 200m or more without any intermediate support. (See fig.6.2).

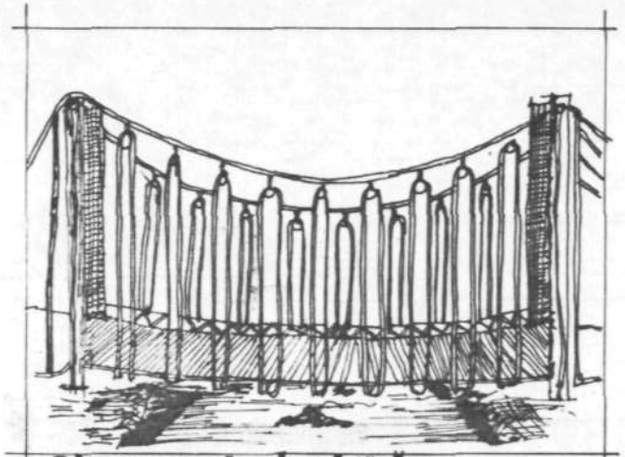
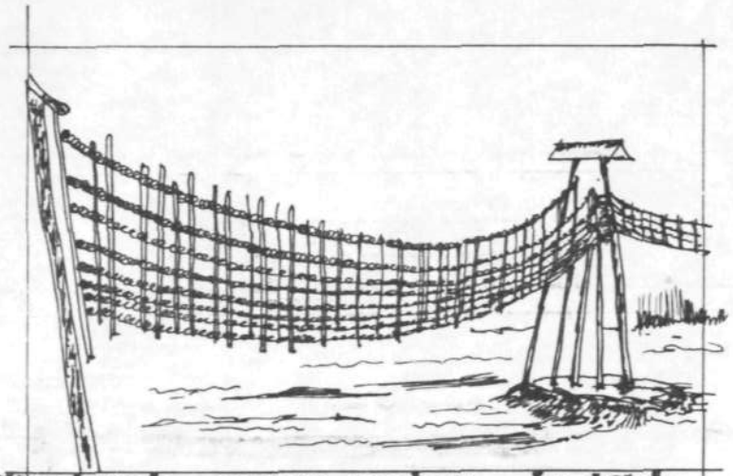


FIG 5:1 channel brigde



ancient suspension brigde

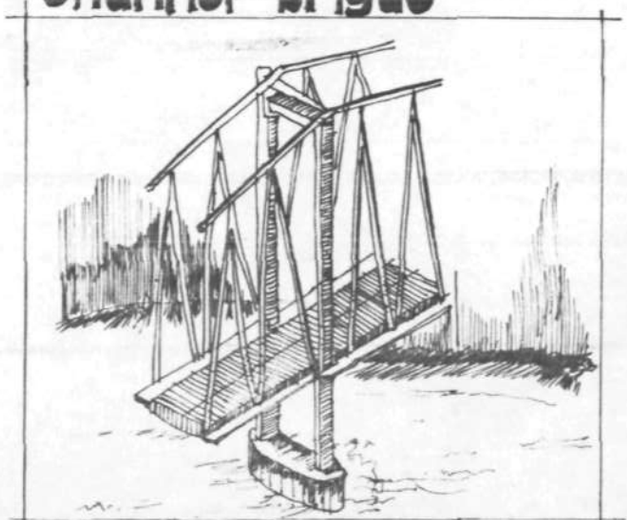
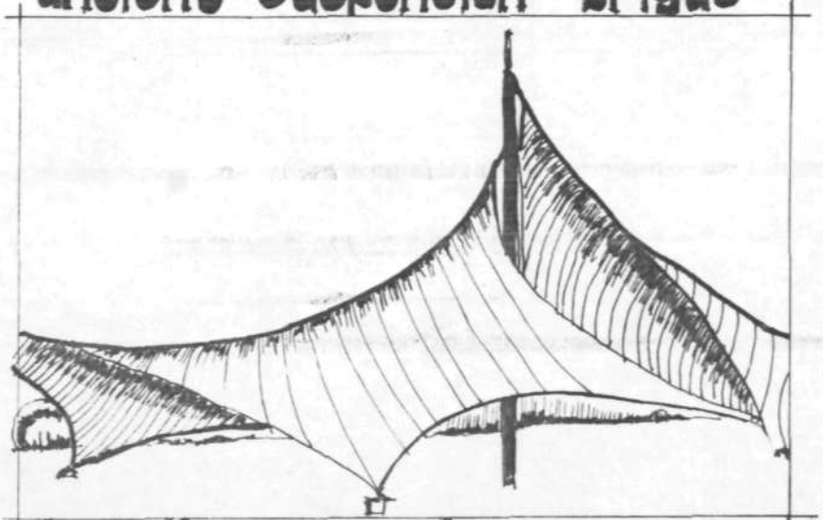


FIG 6:2 mordern const.



tensile membrane

Its principle consist of providing complete rigidity of form by the use of saddle shaped surfaces (especially hyperbolic paraboloidal plan or lattices).

The technological development of materials in form of plastic, steel, rubber, polymers, concrete etc. has given a new direction to architects and engineers in finding a way of exploiting this technology at a minimal cost.

The first modern example of architectural engineering utilizing this concept was the Raliegh arena built in 1952-3 by architects Reirick and Nowicki. The special feature of this roof is its light weight roofing and coverage (See fig. 6.3).

6.1 Space Structure (Cable)

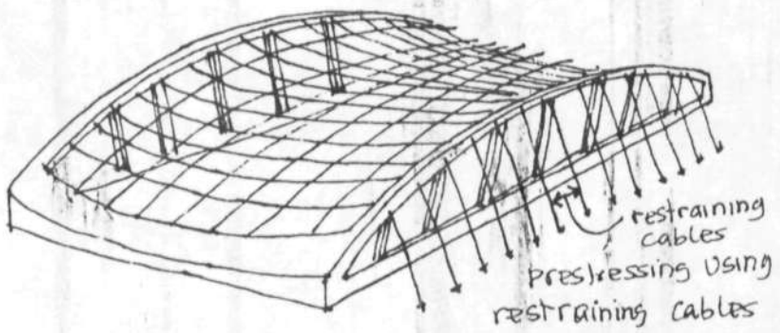
Suspended cable is classified under space structure. A space structure can be defined as a three dimensional assemblage of elements resisting loads which can be applied to any point, inclined at any angle to the surface of the structure and acting in any direction.

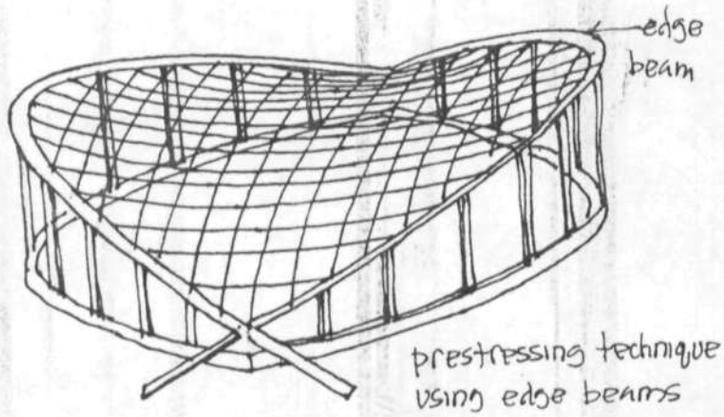
Examples of this include:

a. Skeleton (Braced) frameworks.
b. Stress skim system.
c. Suspended (cable or membrane) structure.

These three groups have been classified to form the next age of architectural engineering development. The engineer has an enormous task in conception looking at the rigorous

PRESTRESSING TECHNIQUES





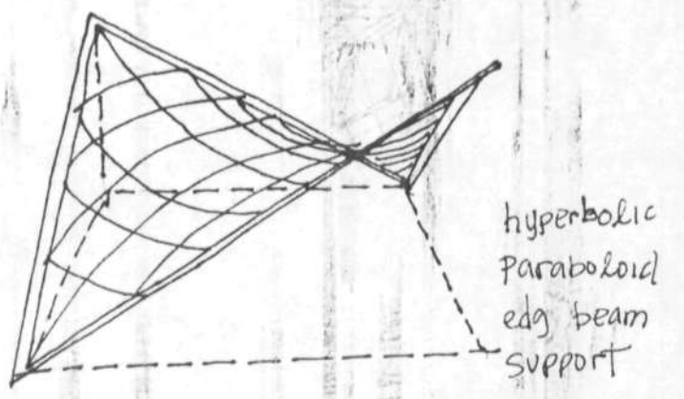


fig 6:3

calculus he will build in translating forces, dynamic and static into a balance state of equilibrium.

6.1.1 Characteristic of cable net

The major problem of cable structure is its behaviour under loading. The engineers have always adopted the non linear approach to tackle problems such as torsion, movement and shear resistance under loading. The loading system is a major factor in the determination of this basic form.

Because of the reduced tension of cable under tension termed as "anticlastic" cables are ensured that they are prestressed before loading to balance the roofing configuration.

Node, point of intersection of two cables is of utmost importance in the stability of the structure, so to avoid high displacement of nodes, the cables are prestressed as a measure (See fig. 6.3)

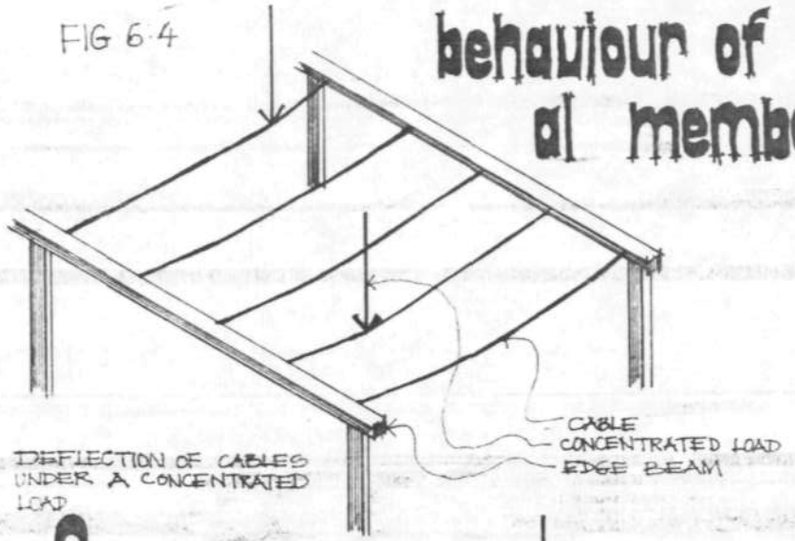
6.1.2 Behaviour of structural members

A look into the behavioural pattern of cable member under various form of loading would reveal their true behaviour.

a. The behaviour of cable under concentrated loading (See fig. 6.4A). This experiment, as explained in the diagram shows that every member cable deflect under different loading. Restraint system should be used to make the cable act together under loading.

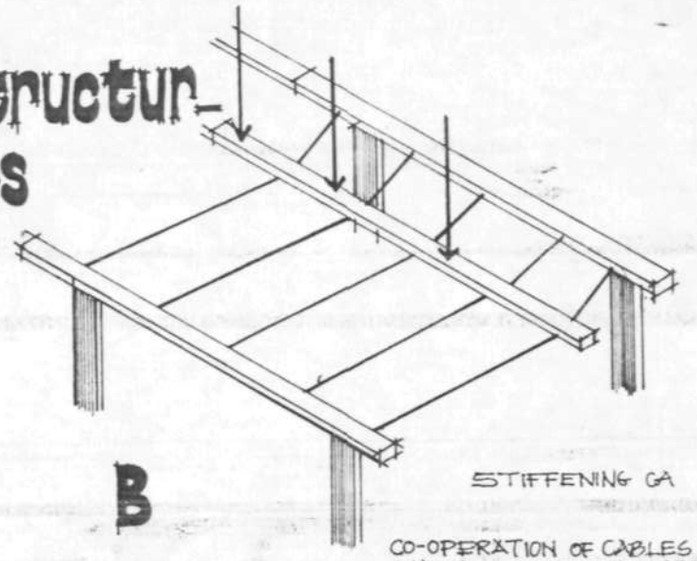
FIG 6·4

behaviour of structur- al members



DEFLECTION OF CABLES UNDER A CONCENTRATED LOAD

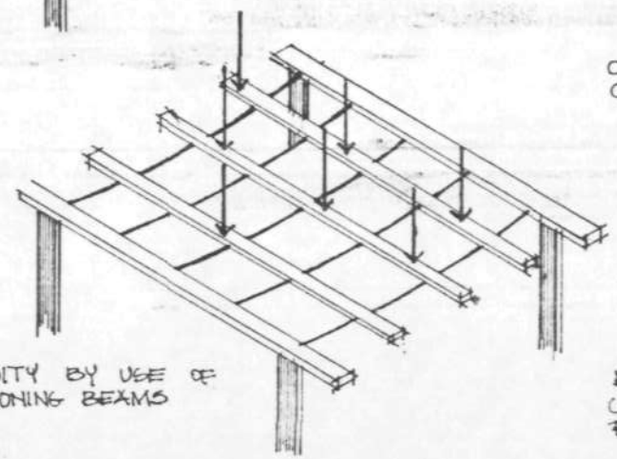
A



B

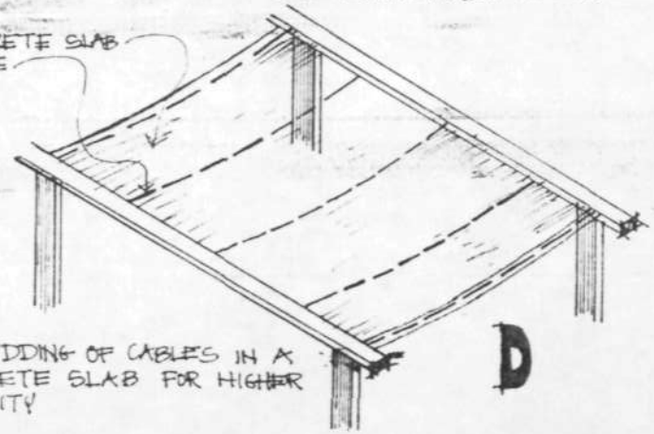
STIFFENING GA

CO-OPERATION OF CABLES UNDER CONCETRATED LOADING



C

INCREASE IN RIGIDITY BY USE OF ADDITIONAL TENSIONING BEAMS



EBEDDING OF CABLES IN A CONCRETE SLAB FOR HIGHER RIGIDITY

D

b. In this diagram (See fig.6.4B) the action of the members when co-operated and subjected to a concentrated loading was observed. The behaviour of this system was found to be highly rigid compared to the first experiment.

c. For higher rigidity tensional members are added (See fig.6.4C) which allows loading to be flexible.

d. The last diagram (See fig.6.4C) explains the method of higher rigidity by embedding the cables, in a concrete slab to protect them against vibration, fluttering or assymetrical loading.

6.2 Advantages of Cable Structures

i. Has lower material usage 5 - 10 kg/m^2.

ii. It can span large area without any intermediate support between 50 - 600m.

iii. The cost of the structure is relatively low.

iv. It can easily be scaffolded.

v. It gives interesting architectural forms.

Disadvantages

i. Wind action resulting in vibration and fluttering.

ii. Assymetrical loading.

iii. Change in temperature.

iv. Dynamic movements.

Defects remedy

As part of the strong effort in tackling these problems, the following measures have been introduced.

a. Damping.

b. Prestressing of cable members.

6.3 Damping

Wind action on buildings

One of the demise of good architectural designs is the wind deformation of its elements caused by the lateral loading of the wind action.

Designers have often atimes neglected applying the safety factor of wind defect in their design but rather concentrate on aesthetics of composite elements. Generation of new ideas in the field of wind design if properly applied would save the architect time and money in facing an arbitration panel.

It is agreed that only by eliminating resonance effect in a structure that stability would be achieved. So for a balanced design, the study of the environmental factors would reveal to a great extent the measures and advantages of the local conditions.

All these measures when taken shall broaden the designer's mind on those lacking elements he has to develop as design parameter (See fig.6-6).

6.3.1 Action on frame buildings

In frame buildings, it is only through the rigidity of structural frames such as beams, slabs, columns and other building elements that deformation of the building whole could be avoided.

Generally in frame buildings the deformation due to lateral drift of the wind is primarily due to the following factors:

a. Bending moment in the girder (60% of the total load), and bending moment in the columns (15%).

b. Axial stresses due to the overturning moment resulting in column shortening and lengthening (20%).

6.3.2 Measures of deformation

1. Design should be such that it respond to this wind action in order to control wrackling of partitions, windows and other forms of building movement.

2. Increasing the rigidity of the structural frames by combining vertical shear truss to the structural frames. Lateral sway is reduced by 50% when a rigid frame is combined with a shear truss. (See fig.6:6).

6.4 Damping Definition

Damping by definition in acoustic is the action by which the vibration in a string is checked or deadened.

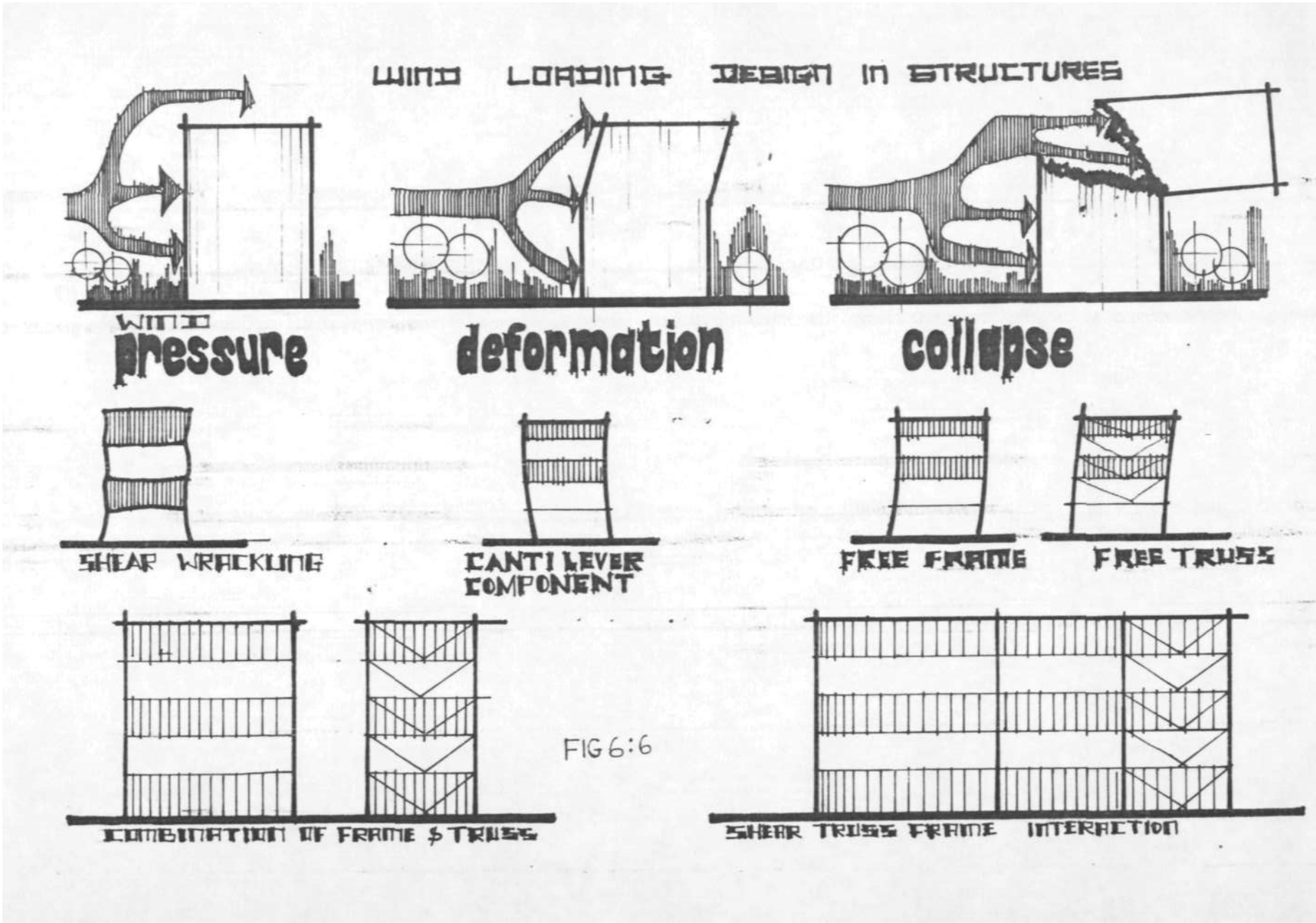

WIND LOADING DESIGN IN STRUCTURES
WIND
pressure
deformation
collapse
SHEAR WRACKING
CANTILEVER COMPONENT
FREE FRAME
FREE TRUSS
COMBINATION OF FRAME & TRUSS
SHEAR TRUSS FRAME INTERACTION

FIG 6:6

The damping system involves a structure which is separated from the basic structure of the building added as a stabilizer. All dampers could be taken out and the building would stand, these; people could work in it without difficulty. But without dampers some people would perceive building motion during period of high wind.

Four types of damping in buildings

(a) Material damping from structural frame.
(b) Damping from partitions, exterior walls.
(c) Aerodynamic damping.
(d) Added damping.

It has been established that there is little self damping of materials in structure because of the elastic nature of structure.

Damping in non structural materials result out of sliding of materials as building moves e.g the movement of glass wall in its rubber edge; the friction of partition as they slide; the cracking of non-structural parts, such as mansory shaft enclosure.

Aerodynamic damping is associated with the building shape. Irregular shaped buildings have higher aerodynamic damping than smooth, uniform shapes. Some have uniform negative aerodynamic damping that the smooth uniform shapes. Some have negative aerodynamic damping; that is they not only do not damp oscillations, they enhance the tendency to oscillate.

Added damper, this is associative in automobiles, door jambing which comes from the hinge etc.

6.4.1 Reason for damping

For a particular peak hour wind excitation, which is critical in buildings, damping helps in reducing such excitation to its bearest minimum. Excitation results in buildings due to vortex shedding, it is also manifested in galloping situations.

Vortex excitation results from the shedding of vortices in a periodic relationship with the shedding frequency being dependent on the shape and size of the building. If this frequency happens to be near the natural frequency of the structure, then it will oscillates back and forth transverse to the wind flow. (See fig.6.6).

The effect of reduced damping in building is high dynamic response. This means that there is total response to deflection, acceleration, stresses etc which are termed defect parameters. For higher excursion a rigidity formular should be sought to reduce induction of dynamic motion in cladding partitions of the building.

The damping in a building should be such that it has high wind vibration capacity than the wind itself. This measure reduces oscillation that the wind might induce into it if it were weak.

Conclusion

In the damping technology in building discussed, it should be understood that damping does not prevent vibration of instrument but reduces it to a negligible state.

6.5 Damping In Suspension Roofs

Light weight roofings are seen as the derivative of old suspension bridges which were exploited by architects to solve the problem of spanning in roof design. There is a critical effect of wind action blowing over the structure, this causes vibration, fluttering and other forms of movement. The aerodynamic instability of light roof deck affects the whole roofing and the structural system. The criticality of wind induced vibration lies in its disturbance of the structural systems if their frequencies are allowed to reach the natural frequency of the structure thereby causing resonance. At resonance the amplitude of vibration increases hyperbolically until failure occurs.

The solution to this resonance effect could be achieved by calculating the frequency of the induced vibrations, so that structural design avoids this frequency. But unfortunately this natural frequency is difficult to calculate because of the large spectrum of potential forces.

The most reliable method consists of a system where the main and the secondary cables are combined so that there is simultaneous exchange of energy between them by any wind action. This approach completely tackles resonance generated

DAMPING TECHNIQUES IN SUSPENSION CABLE

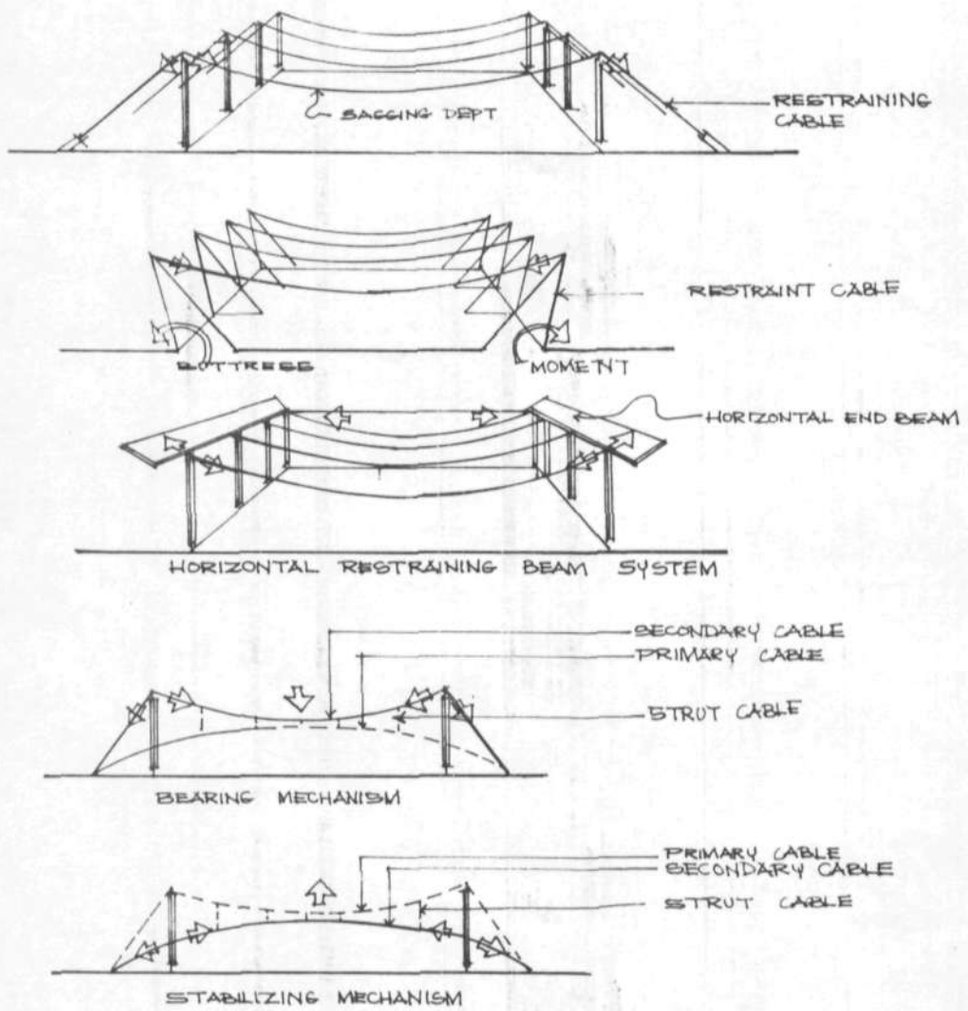


FIG 6:5

problems. The basic principle employed is the transfer of energy from the secondary cable directly connected to deck of the main cables. The secondary and the main cables are made to have different frequencies. The connection of the primary cable to the secondary one is to make sure that their frequencies are at polarity always. So at any point in time, the two cables vibrate at different geometrical shapes. A damping effect results from the actions of these cables, thus creating stability (See fig. 6.5).

6.6 Cable System

The cable technology commonly used in architecture were found to fall within the following classification:

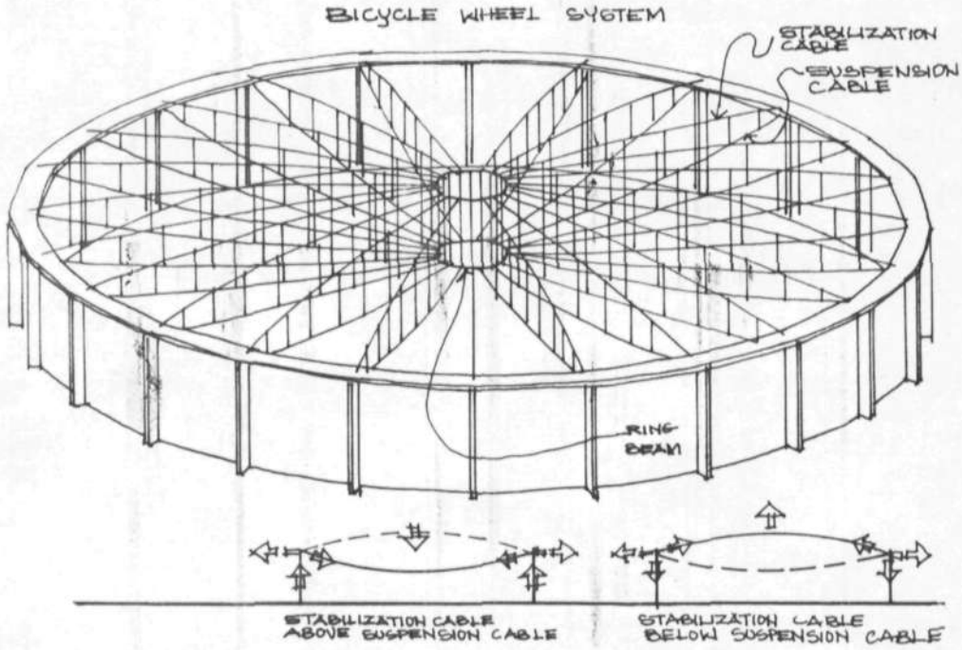
(a) Single layer cable system.
(b) Double layer cable system.
(c) Net system.

(a) Single layer cable system: In this system, single layer cable is used to span two intermediate supports. For a good workability of the system, appropriate cable size should be selected, this enhances the rigidity of the structural system.

Stability in the structure is best achieved by embedding the cables in a concrete slab of appropriate thickness to allow cooperation of the members. Demand and situations are the determinant of choice. (See fig.).

DOUBLE LAYERS CABLE SYSTEM

BICYCLE WHEEL SYSTEM



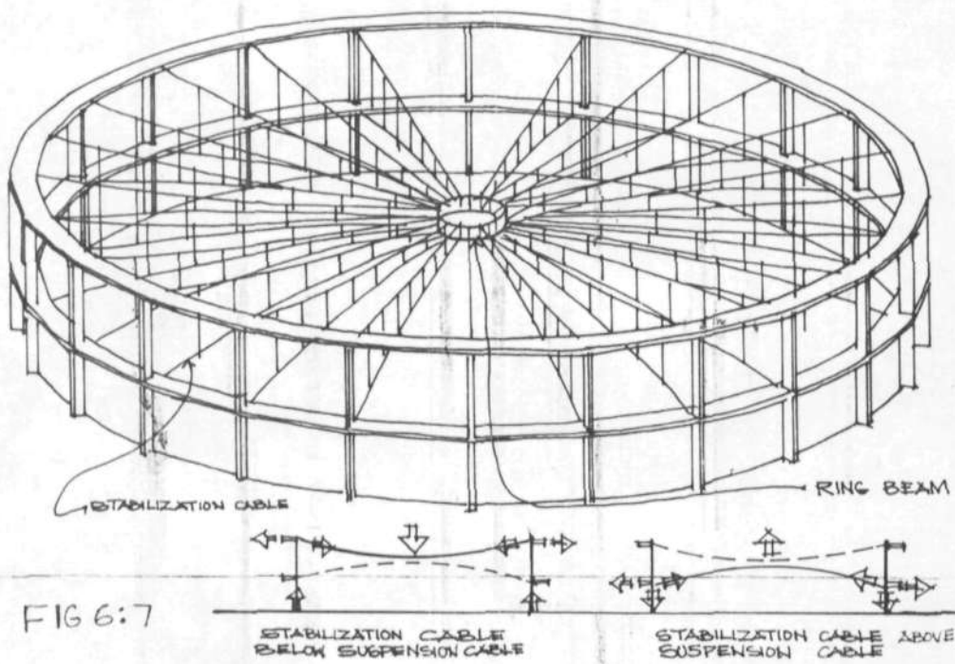


FIG 6:7

(b) Double layer cable system: The system employs double cable for its stability. Major and minor cables are the two sets employed to cooperate in a harmonious whole, distributing loads at various intervals.

Because of their co-operate action they are made to have different diameters. These two sets are connected and separated by a strut member system. This member, when there is little dynamic motion or loading, distributes this effect equally in the two sets. Failure in this system can only come from the structure itself not from the cable system. Circular structures are found to be highly adaptable for this system. (See fig.67).

(c) Cable net system: In this system network of cables spanning in opposite direction are used. The netting system allows for a larger span coverage, because rigidity is enhanced through the intricate netting system.

The critical point of this design lies in the determination of the basic form to be used, when selected, the covering would give the designer the true taste of space structure. (See fig.).

6.7 Types Of Cable Support System

Basically the type of design and the intention of the designer necessitate the type of support to be used. In carrying out format of his design, the architect undergo

analysis of various support systems and try to show their contiguity with other structural elements. Thus, variant selection comes up as a deterministic factor in his design concept.

As apart of the analysis of the contemporary roofing system and their types, four basic types of support systems were found to be dominantly used, these are:

(a) One point support system.
(b) Pheripheral support system.
(c) Spine support system.
(d) Multi point support system.

6.7.1 One point support system

In the one point support system the main structural member transmitting the load is located at the centre or at the pheriphery of the structure. The cable roofing system radiates from this focal point support rigidly held to cover the area required by the boundary support system. A good example of this is the Yoyogi sports arena (minor gymnasium) designed by architect Kenzo Tange. (See fig.6.8).

6.7.2 Pheripheral support system

This form of cable suspension permits the cable to be suspended between two opposite structural supports. In this case, the cable members are tensioned and prestressed to the required sagging depth of the design requirement. To achieve a balance, the pheripheral walls must be positioned

one point cable support system

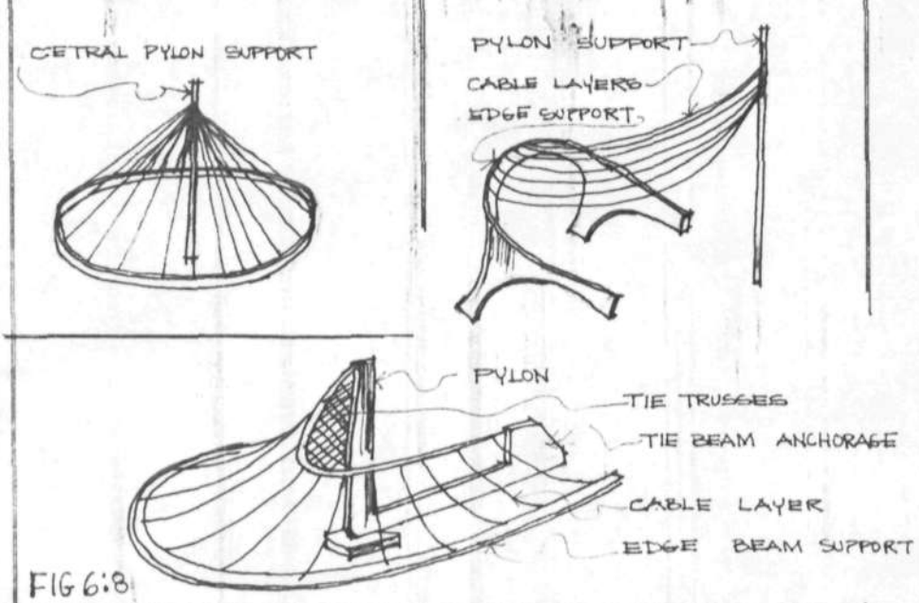
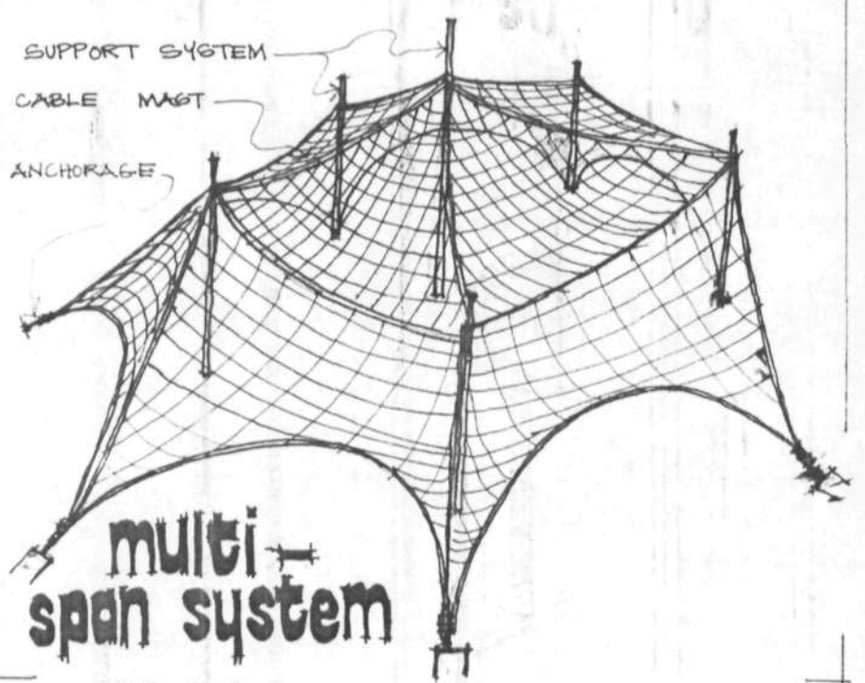


FIG 6:8



multi-span system

FIG 6:9

in such a way that height problem does not create sagging and wind vibration defects. In most cases the pheripheral walls are prestressed to avoid any high buckling due to cable tensional forces. (See fig.6.10).

6.7.3 Spine support system

This concept relies on the provision of a central spine support system in which cables are suspended from the boundary structural support. This system introduces flexibility in creating an interesting architectural expression. (See fig.6.11)

6.7.4 Multi-point support system

This system is adopted in a situation where membrane or cable net structure is required to cover large space for an exhibition, permanent or temporary.

The support system adopted are in multiples and self standing where cable structure or membrane is spread over these supports. For a better understanding a look into Freiotto's work would help the situation. (See fig.6.9).

6.8 Prestressing In Cables

Prestressing

Prestressing is a system adopted to induce an additional stress in structural members with a view of increasing their load bearing capacity. For a larger span coverage, beams, slabs, columns etc, are prestressed either to reduce shearing stress, buckling, torsion, bending stress

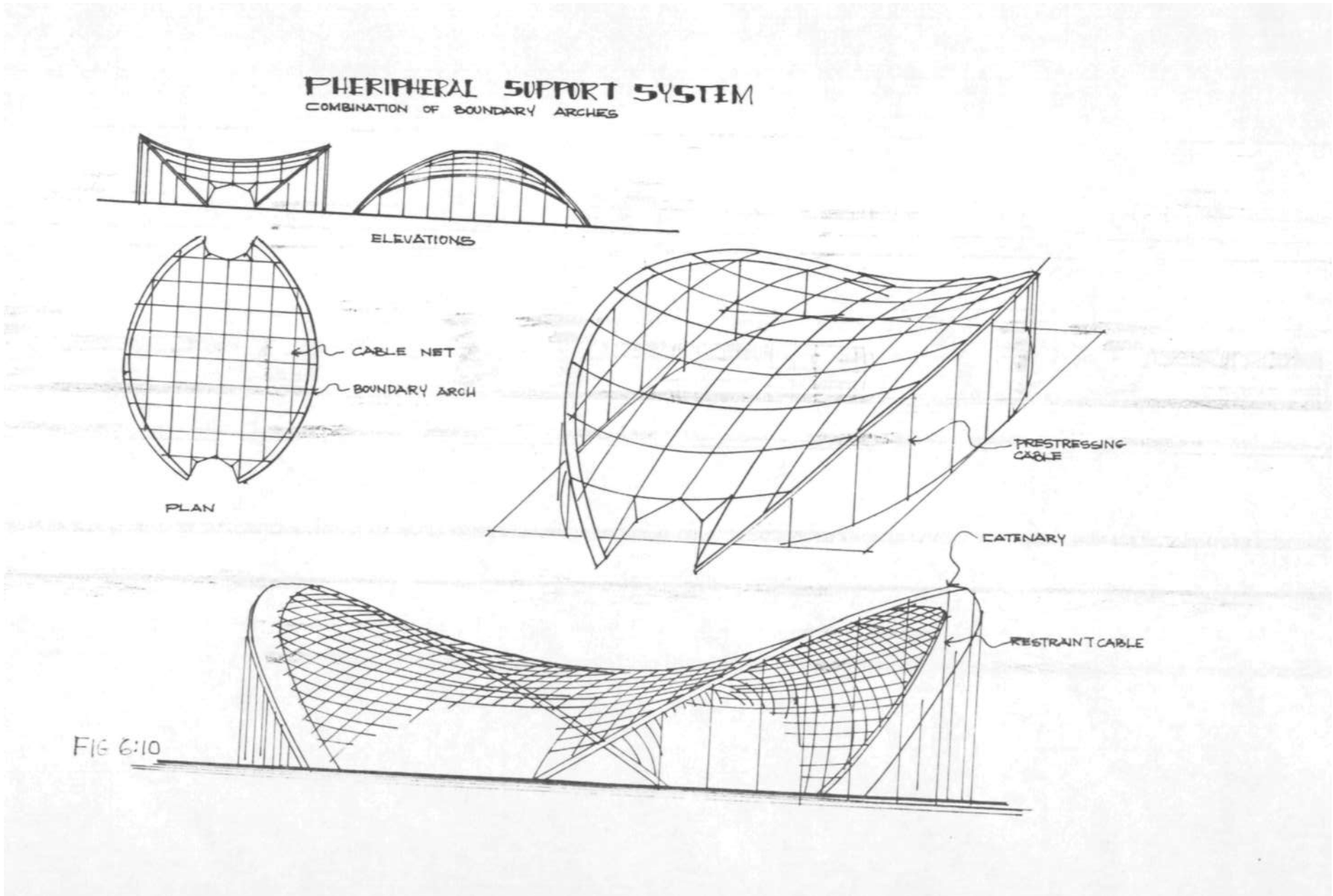

PHERIPHERAL SUPPORT SYSTEM
COMBINATION OF BOUNDARY ARCHES
ELEVATIONS
CABLE NET
BOUNDARY ARCH
PLAN
PRESTRESSING CABLE
CATENARY
RESTRAINT CABLE

FIG 6:10

etc which are associated with structural stability. (See fig.).

Types of prestressing

There are two types of prestressing system currently in use by engineers; these are:

i. Pre-tensioning.
ii. Post-tensioning.

6.8 Pre-tensioning

In pre-tensioning tendon wires are stretched in a mould before concrete is cast. The required tension in the tendons is based on the required stress calculated as an addition to the strength of the concrete to withstand the loading effect.

These tendons are stretched with the help of a hydraulic jack held between the two opposite end of the mould before casting the concrete. After casting and allowed to set for some time, the tendon wires are then released from the hydraulic jack. The tendon wires in trying to regain their original length, induce a compressive strength into the concrete member.

This method allows the concrete member to withstand a great amount of load with a small section. (See fig.).

SPINE SUPPORT SYSTEM

COMBINATION OF TWO BOUNDARY ARCHES WITH A CENTRAL ARCH

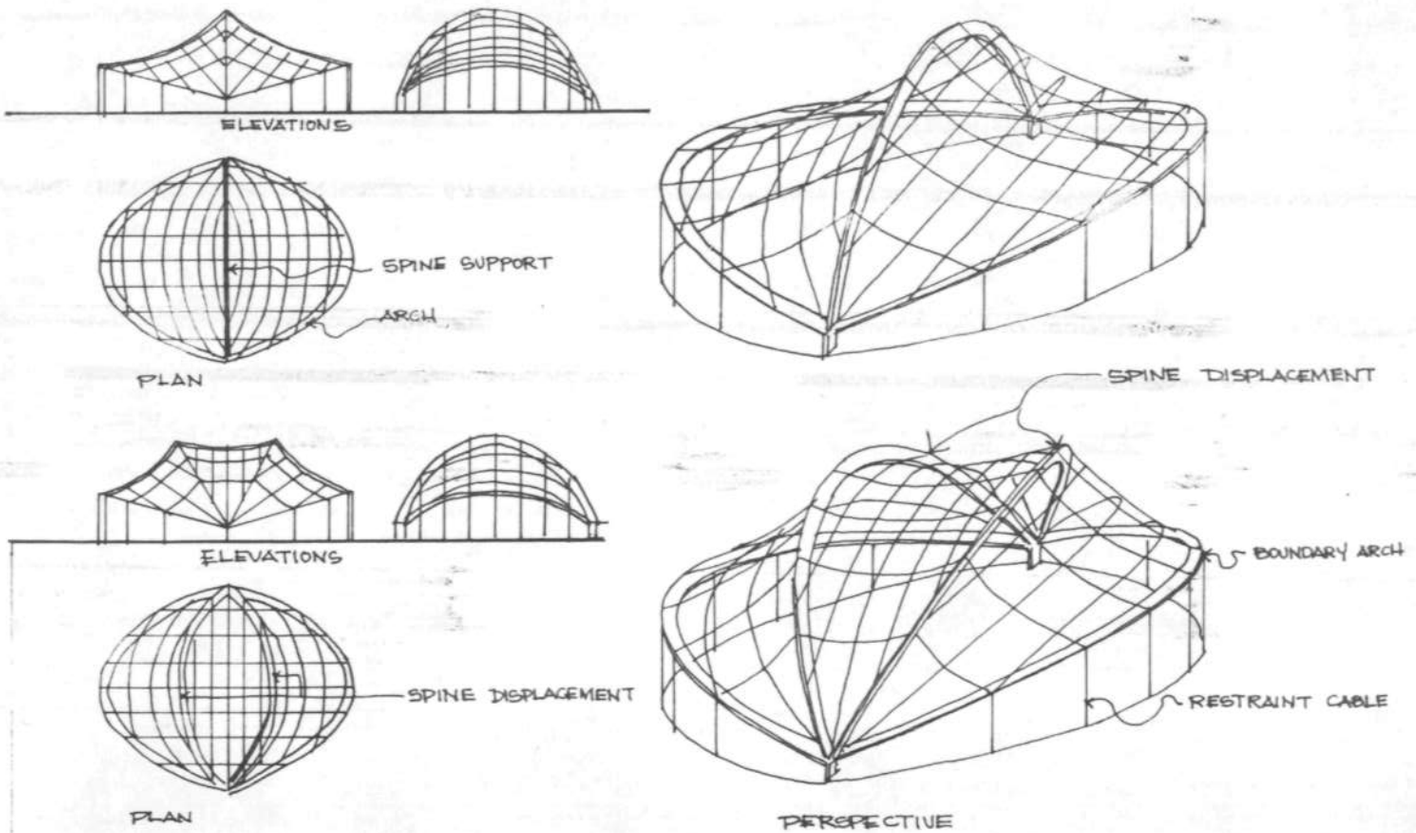


FIG 6:11

Post tensioning

In this system wires are introduced into the concrete member after setting. the wires may be bonded to the concrete or left unbonded.

The tendon channel is made with an inflatable rubber tubing which can be removed after the concrete has set. Tendon wires are introduced into the channel and held by a special anchor devise before jacking with an hydraulic jack. Tension is introduced into the member after the jack is released. Grout is injected subsequently into the channel to prevent tendons rust. (See fig. 6:12).

Prestressing in cable

The major problem of cable structure stability is the wind and load action. In loading, the cable tends to change no character that is noticeable (exhibiting anticlasticism). To overcome this behaviour, the cable is prestressed to a required level of stability. For wind loading problem damping systems are installed to reduce resonance vibration.

Prestressing as a measure in cable structure adds to form determinism and reduce elemental deformation. (See fig. 6:13).

PRESTRESSING TECHNIQUE IN CONCRETE

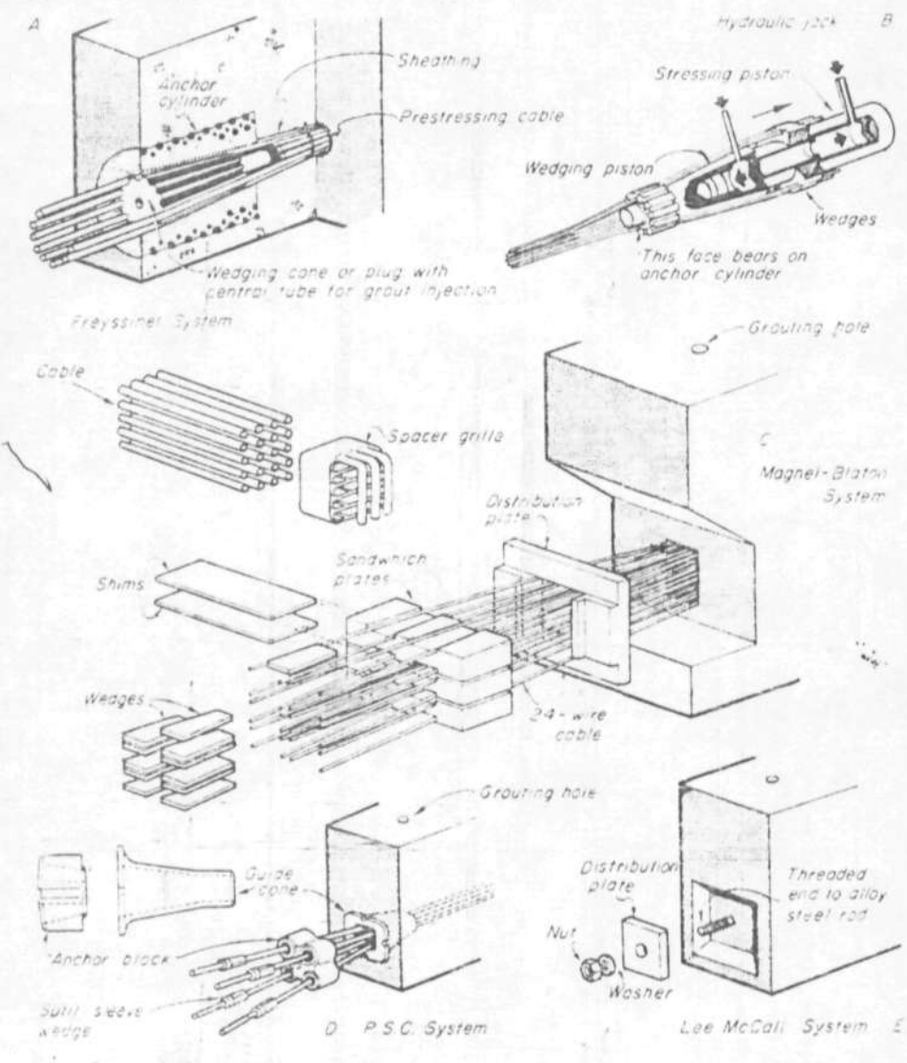
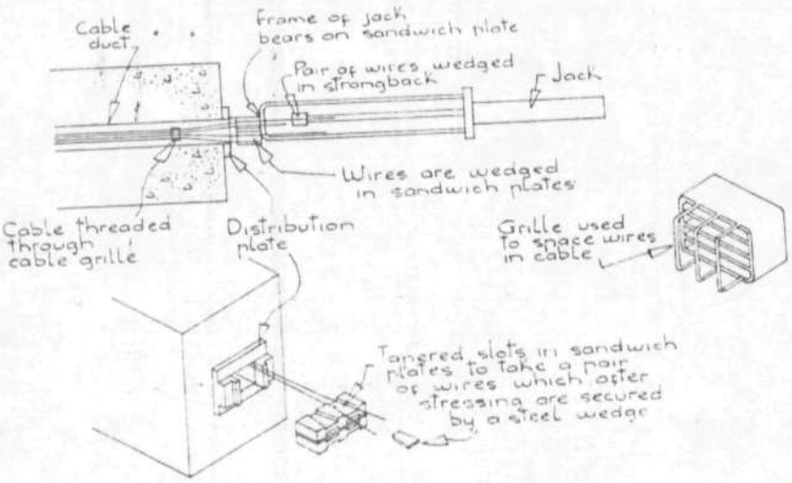


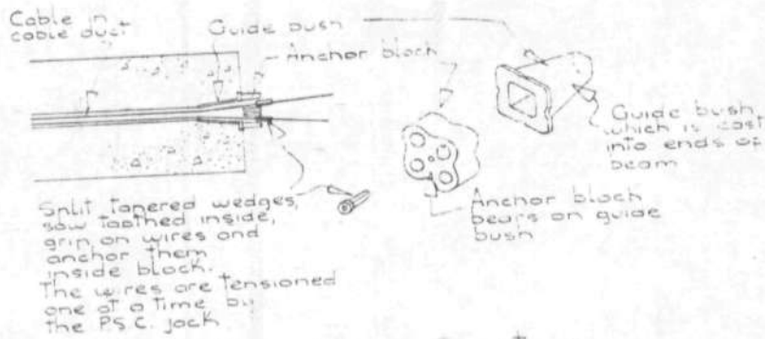
FIG 6:12

PRESTRESSING CONCRETE MEMBERS



Magnel - Blaton System

Fig. 83



P. S. C One Wire System

FIG 6:13

CHAPTER SEVEN

CASE STUDIES

7.1 Minor Gymnasium of Tokyo Olympic Stadium

Introduction

The minor and the major gymnasium designed for summer olympic in 1964 had specialised cable roofing system. The two stadia had a capacity of 4,000 and 15,000 seats respectively. The architect (Kenzo) tries to show that cost which is a major design problem had to be minimized by devising special techniques in the handling of details involved.

7.1.1 Feature of the roof detail

The most delicate problem encountered by the engineers is the determination of the basic configuration of the roofing. Since the roof is of special interest work has to be done to see that this problem is solved. The architect and the engineers did through countless efforts used test model to arrive at the final shape.

Its form is similar to a circular membrane picked at the circumference (See fig.7.1), each hanging roof member is made to suspend from the single abutment zone to the centripetal part of the structure. The form outlines of this suspension scheme give a spiral configuration outlook (See fig.7.1).

ROOF CONSTRUCTION SYSTEM

MINOR GYMNASIUM

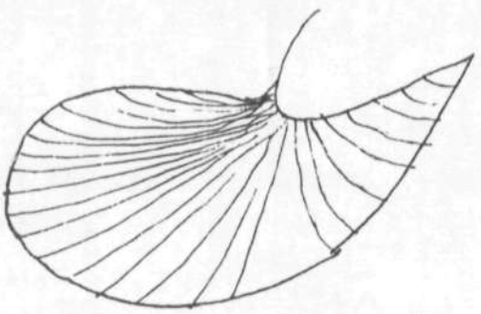


fig 7:1 Element of roof covering

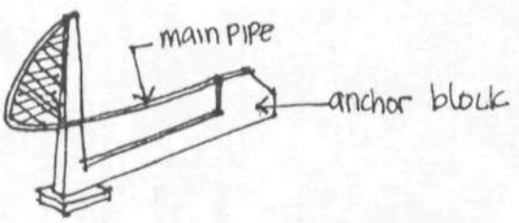


fig 7:2 Element of structural support

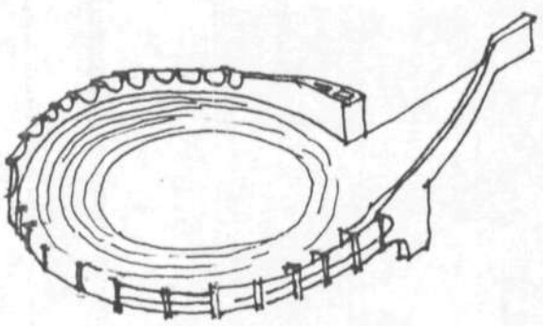


fig 7:3 grand stand structure

7.1.2 Outline of structure

The structure consist of a conical shaped grand stand of 65m diameter and a banging roofing covering both areas. (See fig.7:3).

The structural determination starts by locating the position of the main column which does the load bearing. After locating the column at the circumference of the building, main pipe is then suspended from the main column (as a column) to pass through the centre line of the column following a spiral curve and extended to an anchorage at the tail end (See fig.7·2). Minor cables are then suspended from the main pipe to the circumference of the grandstand at certain intervals. The total roof dead load transmission is done through the main pipe to the self standing column (See fig. 7·2).

The stability of the self standing column was of main concern to the success of the project, so to overcome lateral forces at the top which might result in great bending moment at the bottom due to the cantilevering nature of the support, a tie beam of heavy section was introduced to connect the bottom of the main column to an anchored block. Overturning is overcome by the resistive action of the anchored dead weight and the tie beam (See fig.7·2).

The structure of the grandstand is composed of a series of single leg frames located centripetally towards the centre of the arena and are fixed by a circumferential and bottom

tie rings and double slabs. Thus the whole system completed a rigid closed cone. (See fig.7·3).

The tensinal forces created by the hanging members at the top of the column and the anchor block are transferred to the bottom of the column through the action of the shearing forces in the column and the anial forces of the tie beam. While the horizontal forces of the hanging members along the circumference of the grandstand pushing the cone from the outside are transmitted to the bottom of the column through the axial force and the shearing force of the cone which are in equilibrium with the horizontal forces coming from the top of the column. (See fig.7·2).

7.1.3 Determination of roof shape

The most difficult problem encountered was the determination of the roof form taking into account its architectural elegance, tolerance such as ceiling height, space for roof lighting, location of main pipe in both column plan and elevation, acoustic etc triggered the solution.

To determine the roof form and the forces acting on the constituent members, structural model was used which gives an appropriate location of the members and the forces acting on them. Based on this experimental findings it became possible for the architect and the engineers to establish a governing critaria for its construction. (See fig. 7·3).

Graphical method was used to locate the position of the spiral members hanging from the main column using the

STRUCTURAL DETAIL

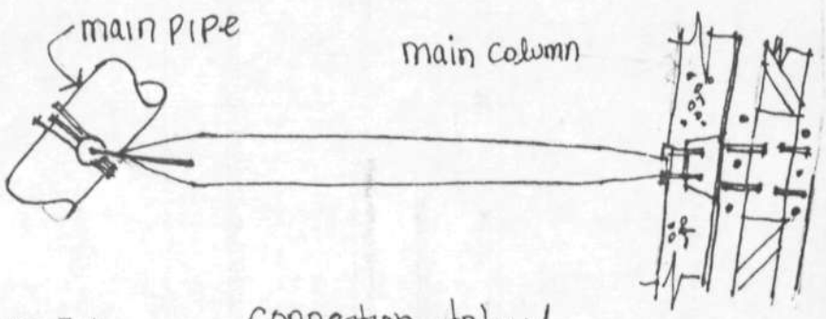


FIG 7:4 connection detail

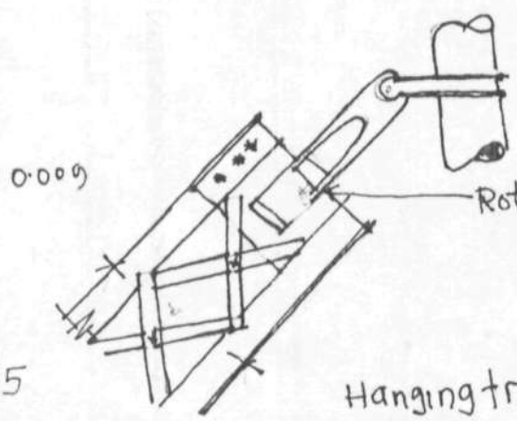


FIG 7:5 Hanging truss detail

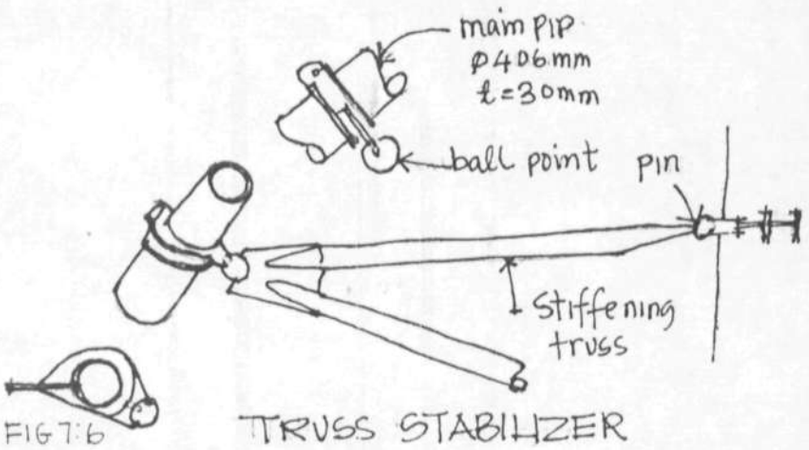


FIG 7:6 TRUSS STABILIZER

horizontal and vertical projection of the resultant force line of the hanging members. (See fig. 7·4).

In order to create rigidity of the elemental hanging members against outside forces, a lattice trussed section of 0.6m depth was adopted while the main steel pipe hanged from the column and braced by horizontal and diagonal members at its upper section.

So with this bracing action both the elemental cable and the main pipe are capable of receiving small bending without any deformation.

7.1.4 Rigidity against wind pressure

The problem associated with wind action on cable structure due to its lightness has to be overcomed by devising methods of rigidity where the wind is reduced considerably. To overcome this problem in the design, a truss system (stiffening truss) consisting of horizontal members and diagonal bracing using pipe was installed between the main column and the spirally curved main pipe. High rigidity created by this method, which makes the whole system behave as a 3-dimensional truss system. (See fig. 7·5).

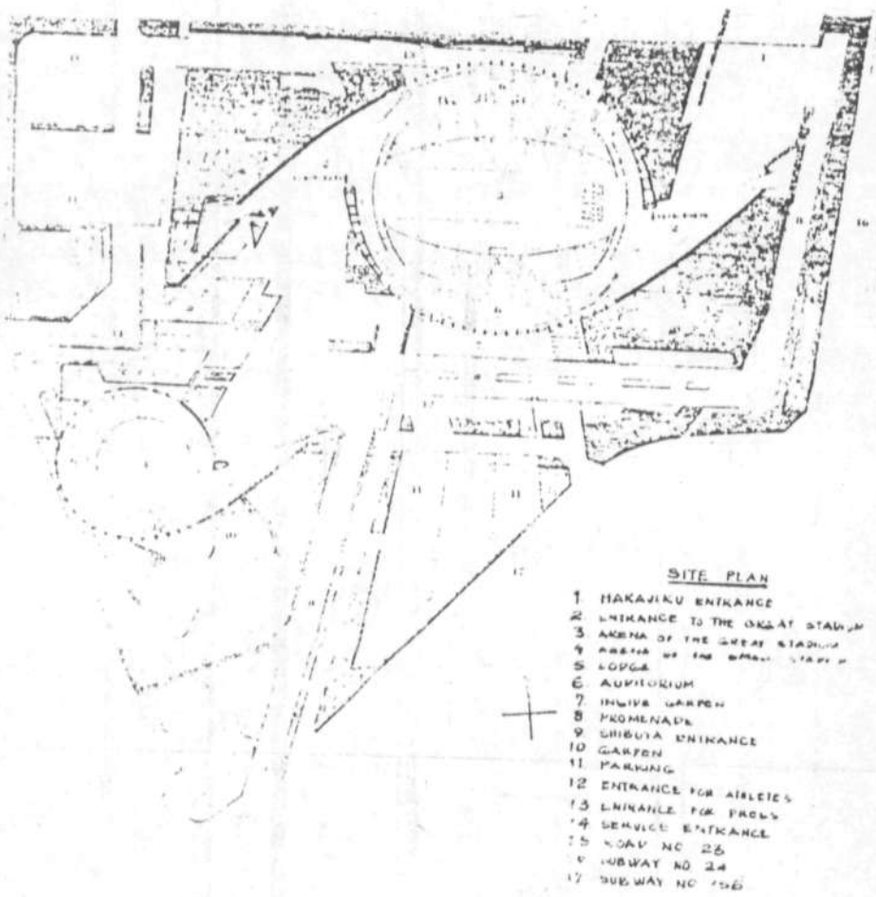
The reason for the adoption of steel pipe instead of rope members for the main hanging members was because of the sliding force and grip problem at the top end of the hanging elements. The angle necessary for the bolting of elemental hanging member would not have been achieved if rope was used, so for better installation rope was avoided.

7.1.5 Major structural details

The main structural member of the roofing, the main pipe, has a diameter of about 400 mm and receives a tension of about 340 tons at the top and 60 tons at the bottom. The elemental rope diameter vary from 30 mm, 25 mm and 2.14 mm.

The greatest technical detail of the project was the connection of the main pipe and the stiffening truss as well as the connection of the elemental ropes to the main pipe. Special details were evolved in an attempt to solve this technical problem. (See fig. 7.6).

One of the problems identified was the connection of the steel trusses at intervals to the curved main pipe. Because of the varying angles of connection to the main pipe, universal section was devised to tackle this problem. For the connection, ring plates were welded to the main pipe, while the stiffening and the hanging trusses were connected to the ring plates utilising steel balls and pin bolts. In order to keep the truss vertical, rotable cylinders were inserted in the end of the hanging trusses. After positioning the trusses, movable parts of the members were welded for rigidity. Paulins of I-section placed transversely to the hanging trusses carrying rafter of I-shape to which the steel roofing plate 3mm thick was welded. In order to avoid thermal stresses resulting from expansion problem, line of expansion folded in a triangular section was devised along the line of the hanging trusses. (See fig. 7.5).



INTERGRATED SITE PLAN OF THE
1964 OLYMPIC ARENA - JAPAN

FIG 7:7

7.1.6 Fabrication and erection

Most of the members used as structural elements such as the pipe and the steel rope were prefabricated to allow for easy and fast erection. Special attention was given to the deformation and stress problem to be encountered by the welding to ensure that adequate permissible tolerance were adhered to. Radio isotope devices which radiate gamma(X) rays were used to check the welding depth and deformation of the steel pipe. Height adjustment devices were used to check the correct position of the trusses on site before welding. (See fig. 7.5).

7.2 Yoyogi Sports Arena (Larger Gymnasium)

As part of the planning concept of the sports arena for the 1964 olympic games, facilities were provided based on the urban planning concept adopted by the architect (Kenzo Tange). This concept tries to draw harmony between facilities and the environment through landscape integration. To this end, the two facilities designed to serve as venues for various events were located side by side. Split level landscape system was designed separately, the pedestrians and the vehicular spectators through bifocation.

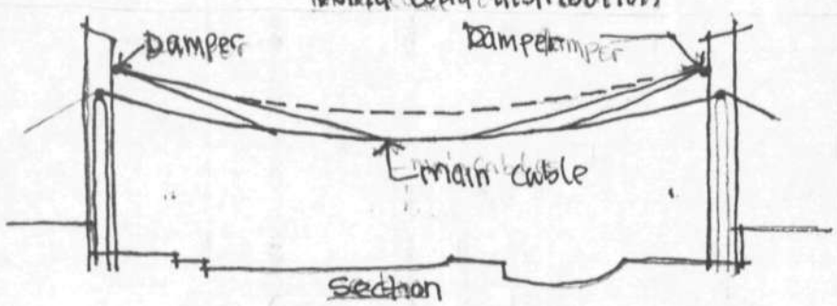
The arena

The larger arena designed for swimming adopted the bridge suspension concept, by having two columns placed 126m apart and a cable member was suspended from one end of

[redacted]MPING SYSTEM



FIG 7:8 Wind load distribution



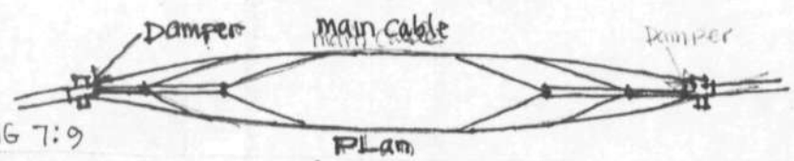


FIG 7:9 PLan

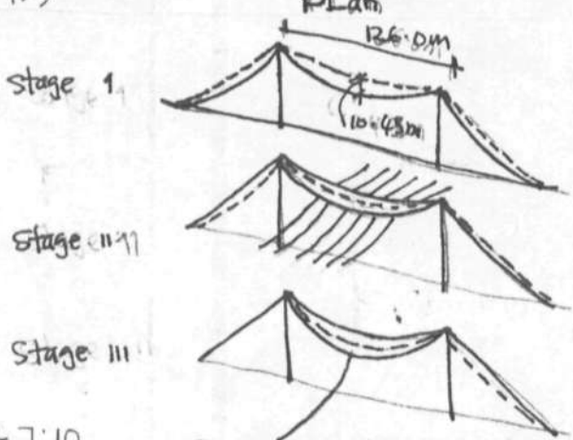


FIG 7:10 STAGES OF CONSTRUCTION

the column to the other through an abutment that serves as an anchorage for the cable suspension. (See fig.7:10). A sag of about 9.63m was recorded at the mid span of the structure. The cables are laid in parallel and spaced at 2.580 apart from the end of columns to about 16.80m at the midspan which gives room for skylights and artificial lights placement. The size of the main cable used is about 330 mm in diameter and consist of 31 ropes of 52 mm diameter and 6 ropes of 34.5 mm diameter.

A series of cable members were suspended from the main cable 4.5m centre to centre to the boundary area of the structure to serve as the roof member. To avoid destabilization of external forces, the cables were thus tensioned to a stress of about 20 - 350 tons. Tensional forces were also induced in the columns to prevent an uplift of the backstay cable under wind action. (See fig.7·9).

7.2.1 Examination of safety factor under wind loadings

As part of the design consciousness, the action of wind on the structure was investigated to determine the pressure coefficient of wind along the roof surface. A model was used to determine this action in a wind turnel. Various desgn coefficient ranging from negative to positive values were found round the surfaces. (See fig. 7:8).

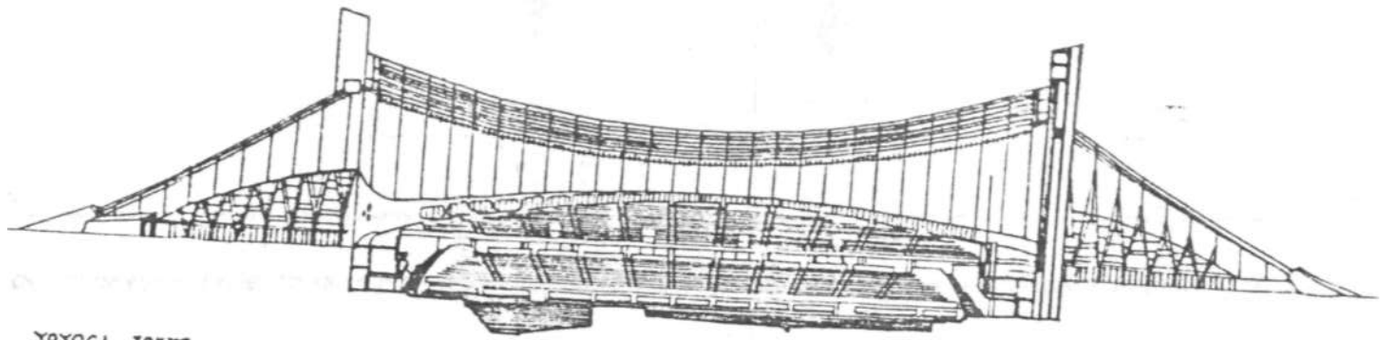
7.2.2 Design of the damping system

As analysed in the wind turnel experiment it was found out that only self-excited vibration was feasible and the resonance between the wind pulsation and the roof vibration. So as a measure against this possible wind defects, a damping restraint system was adopted. As explained in the diagram below dampers were installed at the central portion of the structure to overcome this defect. (See fig.7:8).

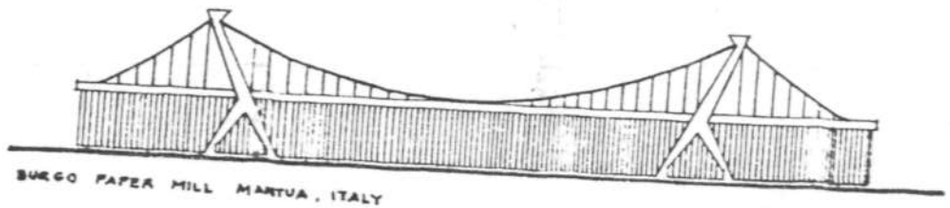
Structural details

The major problem encountered in the design were those du to flexural characteristic of the cable system during construction. Various methods of construction were evolved to overcome this problem by starting the construction on a sequential order.

The two main supporting columns were built first, then wires were suspended from one end of the column to the other end passing through the columns. After passing through the col as they were made to anchor using abutment restraint members. The cables were then adjusted to make sure that they co-operate equally to carry the load. (See fig.7:10). Secondly, after laying, they were then pulled transversely at the central span to create a space between them for lighting. The maximum spacing gap reached about 18m at the central span and maintained by inserting a group of central trusses between them. (See fig. 7:10)



YOYOGI TOKYO JAPAN SECTION OF THE OLYMPIC SWIMMING ARENA



BURGO PAPER MILL MANTUA, ITALY

FIG 7:11

Lastly, secondary cables were suspended to the main cables to act as the roofing members. Prestressing was then interduced to keep the members together.

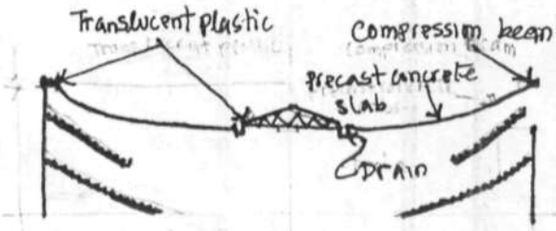
7.3 Montevideo Stadium, Paraguy

This stadium is located in the central city of Paraguy. The basic feature of the stadium is a cylindrical wall of 31.7m high and a diameter of 103.3m. The roof support consists of a reinforced concrete compression ring located on the 4in. reinforced concrete wall surrounding the stadium, a tensile steel ring was placed at the centre and 256 galvanised wire cables radiating between the two rings.

A concrete slab was used to cover the trapezoidal space created by the running of the cables between the two ends. The slabs are put in place by the means of wires tieing them rigidly to the cable and to other slabs.

In order to create a rigid struncture of the cable system, prestressing was introduced by means of a loading technique. The technique consist of loading the cable with bricks, this loading create gaps between slab cover of the roof. Then mortar joint is used to fill up the gap thereby keeping the slabs and the cable rigid. When the bricks are removed the cables try to adjust themselves to their normal position by pressing the mortar joint tight. Insulating roof covering materials were used for the finishing.

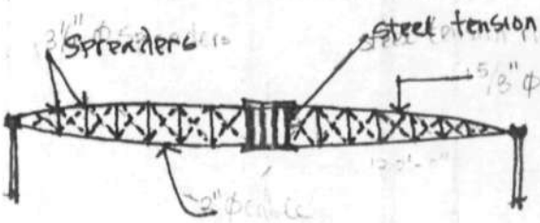
The roof is drained by a throgh system around the central opening and conducted through four pipes hung from the ceiling,



A cross of one layer cable roof

Montevideo stadium
Paraguy

FIG 7:12



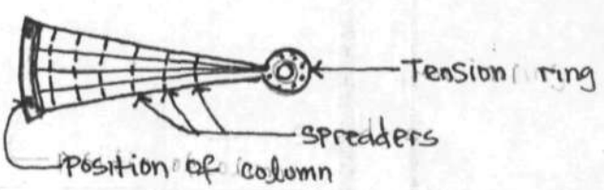
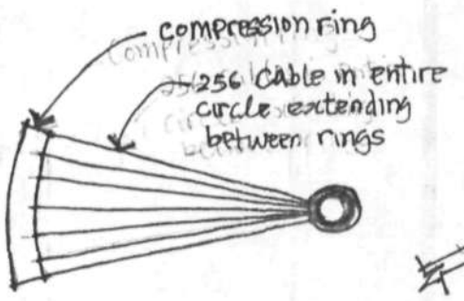
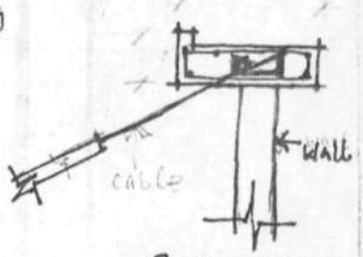


FIG 7:13





Compression ring

FIG 7:14

to down spot on the outside wall into a storm sewer.

The roof was conceived by L.A. Mondino; L.I. Uiera, and Miller of Montevideo. (See fig.7:12).

7.4 (Chicago O'Hare International Airport Restaurant)

Features of the design

A single layer cable system is used by suspending a compressive ring member at the centre of the structure.

The concrete compression member of diameter 63.3m is supported on 26 reinforced concrete columns 19.3m above the ground surface. It has a tension ring, flange shaped of diameter 4.3m, cable of diameter 50m and a length of 17.3m were anchored to the compression tension ring. A slab of 9cm in thickness was used as the roof covering member and held to place by wires attached to the cable. The method of prestressing adopted in the montevideo was adopted. (See fig.7:13).

7.5 Memorial Auditorium, Utica, New York

In this auditorium the double cable system was used to cover a circular structure with a diameter of about 80.0m. The support consists of two 72 cable layers. The cables in both direction are anchored to a reinforced concrete compression ring having a cross section area of about 18 sq. metre, supported on a reinforced concrete column equally spaced around the perimeter of the building and supported laterary.

The compression steel rings 6m apart are held vertically by equally spread steel pipe 5 in. in diameter. Spreader pipes were used to keep the pair of cable intact by spacing them apart concentrically. (See fig.7:13).

After anchoring the cables to the end of tension and compression member, an hydraulic jack is introduced between the rings to keep them apart. Tension in the cable was introduced due to the vertical movement of the hydraulic jack. The stress in the jack was made to fall within a predetermined value. To increase the tension in the member vertical struts were inserted between cables to keep them rigid.

For further rigidity bracing rods were introduced between the struts to safeguard against deflection and vibration.

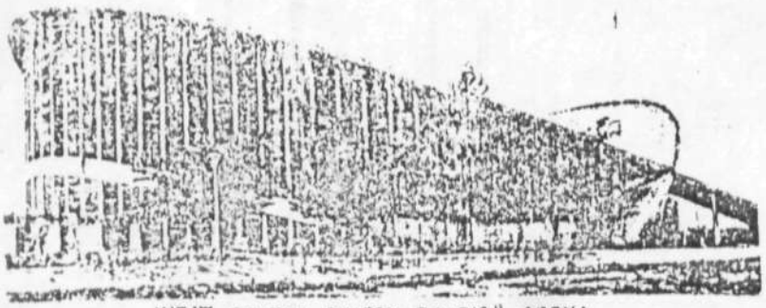
A metal rocfing sheet was finally welded to the cables to serve as the roof covering. (See fig.7:14).

7,5.1 Ice hockey rink, Yale

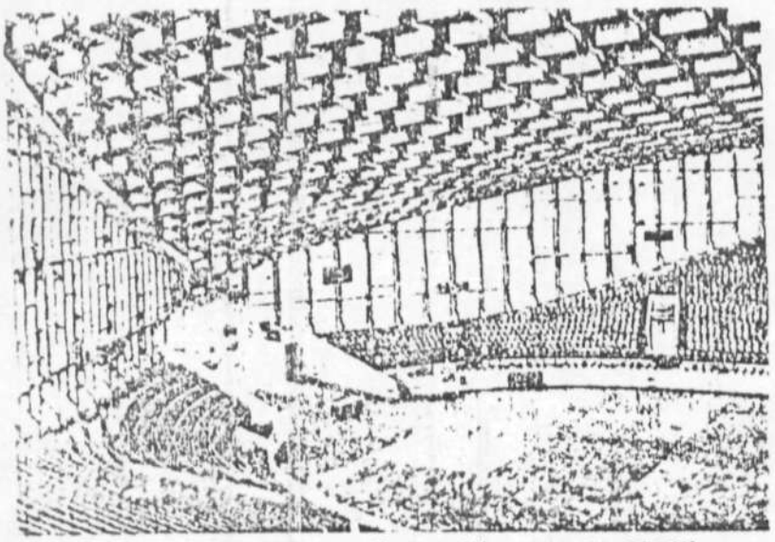
The rink was built in Yale University to accommodate 3,000 spectators, designed by architect Enri Sarinen. It covers an area of 60 x 25(m^2) built on a solid wall.

Design principle

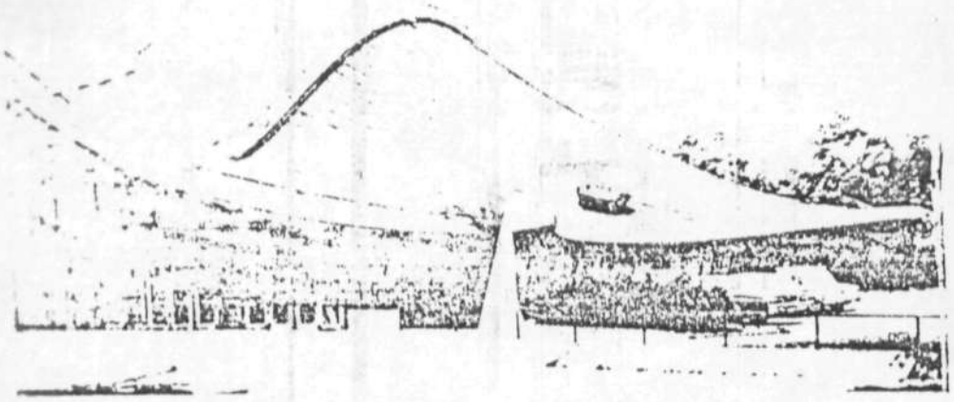
The construction involves a reinforced concrete Parabola rib arch beam which raises to a height of 21m above rink's floor spanning the whole length. Cable roof suspension member were suspended from the arch rib to the pheripheral caternary wall. The cables, 23 mm in diameter were laid at



VIEW OF THE DORTON RALEIGH ARENA



INTERIOR VIEW OF THE DORTON RALEIGH ARENA



THE HOCKEY RINK AT YALE UNIVERSITY U.S.A.

FIG 7:15

an interval of 2m long, tied to a pheripheral wall to form the netw ork system. For structural rigidity and stability, 3 sets of cables 44 mm in diameter were used as bracers. To achieve the required sagging, CF-I Roebling system were employed. Finally the steel cables were encased with timber, fire-proofed tongued and grooved--bonding was nailed on these to complete the roof finishing. (See fig. 7.15).

7.6 Roofing Materials

As part of the designer's requirement, good roofing material chosen for the cable system shall go a long way in reducing cost both initial and maintenance. To this end a careful analysis of the precinct roofing elements shall reduce excesses associated with defect thoughts.

In general these basic factors should be considered in the selection of a roofing system.

7.6.1 Slope of the roof

The basic consideration of roofing slope is drainage, so therefore, materials should be selected so that they are efficient under all forms of weather conditions. Attention to joints and lapping should be a working guidance knowing fully well the implication of leakage.

7.6.2 Types of roof deck

The roof deck and the method of fastening is the governing factor in relating efficiency to economy.

Because ill chosen roofing material will create high construction problem and possibly escalate cost.

7.6.3 Weight of roofing

For cost efficiency the roof weight should be reduced. This major consideration shall play a good role in creating high flexibility.

7.6.4 Climatic condition

The understanding of physical characteristic of a roofing material shall help in reducing problem assiciated with environmental hazard. This problem include wind vibration, thermal expansion and contraction, temperature, humidity etc. As observed, materials like slates, tiles and asbestos cement shingles and asphalt are susceptible to breakage under high wind pressure. In this effect, expansion created by temperature difference adversely affects asphalt shingles roofing.

Special materials like copper, zinc, lead and aluminium are found to be desirable in industrial buildings, whereas, fog, smoke and other gases tend to pullute the environment, therefore material should be well selected to reduce production cost.

7.6.5 Durability

The durability factor of a material is depended on its suitability for the purpose used, other governing factors are climatic conditions, quality of workmanship

in laying, effectiveness of maintenance. These carefully thought out factors would give a good guidance to designers and contractors.

The following roofing materials below are classified according to their durability:

(1) Sheet copper, lead, stainless steel, Aluminium, clay, tile slate, concrete, asbest-protected metal.
(2) Tern plate, galvanised iron, asbestor cement tiles.
(3) Wood shingle.
(4) Asphalt shingle.
(5) Rolling roof.

7.6.6 Cost

One of the major selection factor of roofing sheet is its cost efficiency. A careful understanding of the implication of some decisions would be of utmost importance to the architect. The cost efficiency analysis shall vary as applied in the durability factor above.

7.6.7 Appearance

Good appearance of an architectural work is seen from the ways materials are judiciously used. The choice of roofing system used in a design would highlight the dexterious thought of the designer in the field of aesthetic balance.

7.6.8 Maintenance

One of the aims of selecting a good roofing material after careful consideration is the maintenance period and its cost. It should be noted that the initial cost should not overide the choice of selecting a durable material.

Conclusion

It is viewed that for an effective cost safing technique of the project, an understanding of the cost implication of a selected roofing material would be of utmost importance. So, therefore the constructional detail precinct to the project execution should be carefully laid to avoid any ambiguity inherent thereof.

7.7 Frei Otto

Against the background of cable development within the contemporary period of architectural development, a great insight is made to see how these forms of development came into being. To this end, a look into Frei Otto's work would help in projecting those precinct ideas labelled as technological development. He is seen as a pioneering member in this field looking at the length of time he has spent along this line. His major works span from membrane to cable structures which are regarded as light weight materials in the field of architectural engineering.

7.7.1 Development

Frei is seen as an educator and a researcher looking at his numerous works in the field of architectural technological development. As an experimenter, he heads a school of experimental architecture, Stuggart, Germany, where students are thought the basic tool of technical problem understanding. The participation of both students and research fellows in problem solving in the institute has opened an avenue for idea exchange. The institute along its line of objectives has given every researcher the best medium to express his or her research findings. So, every researcher is autonomous in research findings, but ideas shearing is not restricted by this freedom.

7.7.2 His guiding principles

His long association with this field of development has made him to understand some basic working variants that a designer should know or the ethic he should develop knowing fully well the non stagnant posture of technology.

He believes that much as artistic and technical solutions are brought to problem solution, the flexibility should be a guiding principle for good value judgement of some decisions. His long precinct detail understanding has made him to believe that it is only through experimental architecture that good decision could be valued, this takes the form of model making as an overview. The model, after a critical analysis would let the designer make some key decisions as regard aesthetic and stability.

7.7.3 The use of model

This helps him in establishing the first basic idea on constructional principle. Cable sizes are defined with this framework which aid the prefabrication of the members. With this technique, material excess is reduced to an absolute minimum, thus giving the much needed economic viability.

After deriving the basic form from the bubble diagram series of small material, models are made which give the shape, body and enable him to understand the pros and cons of these forms on site.

After establishing the much needed relationship between the bubble model and the canvas model, structural model is then made to define the stress level in the net and establish the cable length. Great precision is put into this model making by refining it using photographs made at the first stage. This model becomes the last in the design process. A check list is made at times after concluding the model by going back to the initial conception for thorough analysis.

This technique was used for the Montreal Expo ('67) exhibition of German pavillion, which has the advantage of producing a surface with the same tensile force per unit area at all point on the surface.

7.7.4 His basic approach

The knowledge of structure has made him to evolve any form of structure intuitively. This, he uses an extensive armoury of techniques for producing new forms with a simple structural detail. His basic architectural philosophy is based on the fact that form should not be forced on a structure but rather the structure should take a natural form. He believes that the relationship of mass (length/force) is a better tool to judge the ability of the structural capability of a structure, rather than using the stress in the material.

The intuitional forces back up by physic rather than mathematics have become the working tool of his design evolution. Because of this inventive genus, new ideas are totally generated to solve problems at a given time. He is described as a three-in-one architect (the inventor, the architect and the engineer) because of the discussed quality in the text about his creative genius.

7.7.5 His works

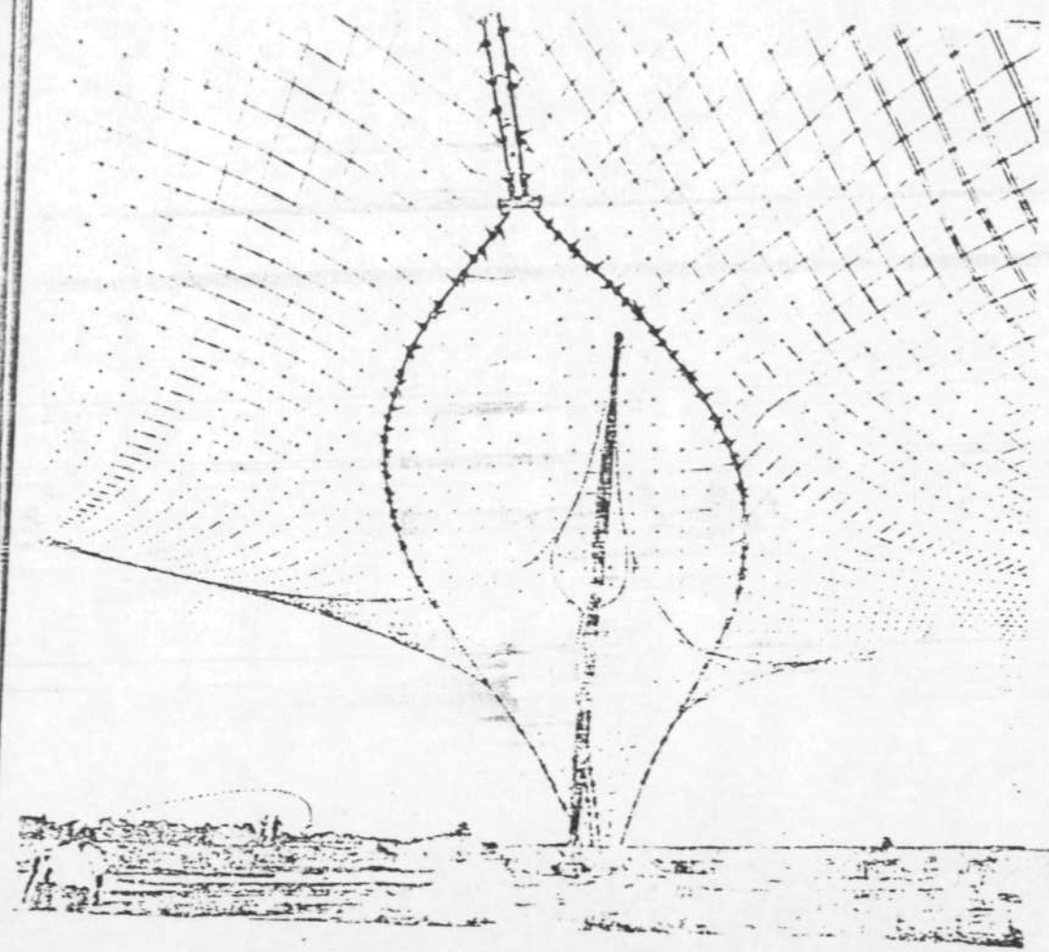
Much as his educational and research ability had helped in cable technology, it is therefore right to bring to focus some of the works that exhibited his inventive genius. These are; (See fig.7:16).

(a) German pavillion Expo '67.

(b) German pavillion Expo '70.

(c) National exhibition Stand Lani Sanne.

(d) Conference centre Kuwait.



THE GERMAN PAVILION AT
EXPO 1967
MONTREAL

FIG 7:16

Conclusion

From the discussion of Frei's works and his inventive genius, it would be right at this point to understant that this creativity in the field of tensile technology has not reached its limit, but rather the changing pattern of technological development should be exploited. In searching for a model form the architect might go ecletic by looking at natural forms, this would guide him in expressing his fantasy. The trend in modern development like the use of computer for data processing would help designers exploit those forms outside their thoughts by employing the variant technique of the computer designer.

7.8 Limitation of cable structure

It could be said that limitation of structural members has become the point to which designers would have to take correction. This has come in form of establishing concrete theory for economical consideration.

Various materials used in the field of architecture have their structural limitations, the elastic theory concepts have become the measurement unit of material performance. The elastic characteristic of every material is considered which shows that as the elastic limit is exceeded strain occurs, an additional load at this point would lead to state of permanent deformation. The stress/strain relationship diagram of every material would guide a designer in making the right selection decision.

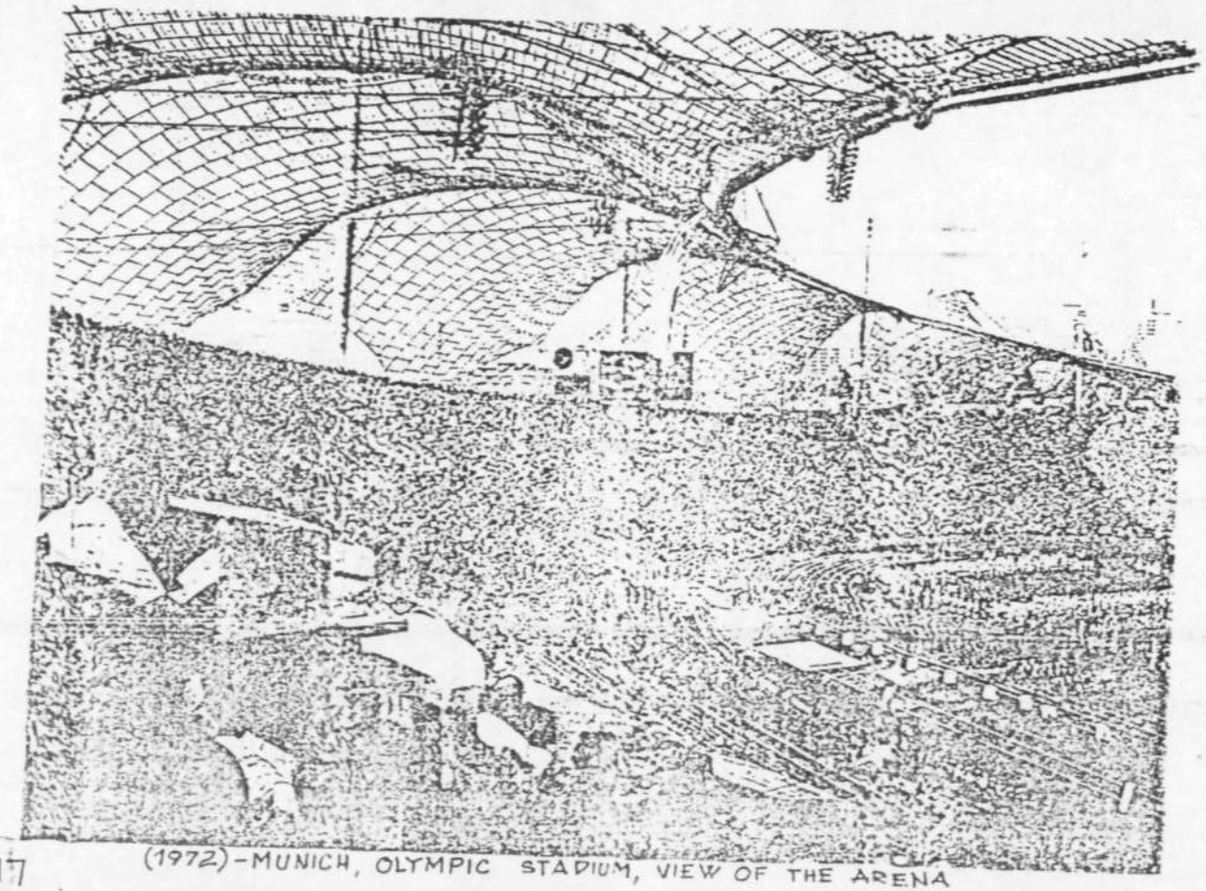


FIG 7:17 (1972)-MUNICH, OLYMPIC STADIUM, VIEW OF THE ARENA

In structural members such as beams, columns and slabs, the limit state theory comes to play in determining the bending, shearing, buckling, torsion and other problems associated with these members. The engineer, with this information in mind would design, making sure the structural members are not susceptible to these defects.

In the roofing system, various forms of roofing methods are employed as solution to span coverage, the architect with his aesthetic principle in mind would select materials based on the limit state theory after due consideration. The roof system such as pith, arch, spaceframe, lattice girder, shells, folded plates, geodesic dome, cable, nenmatic etc. have their various advantages and disadvantages in due consideration.

Cable has the advantage of spanning larger span 5 - 10 km after due consideration of tensional forces in the cable and its cross-sectional area. The versatile nature of this, has made it possible to use small amount of the material to achieve flexibility in the covering of any form with spanning problem.

This advantage has made it possible for engineers to employ it in the field of bridge constructions where spanning and economy are considered. An example of this engineering feat is the Verrano-narrow bridge in New York spanning 1299m and the Messina bridge spanning 1524m.

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The understanding of materials limit state theory would give the designer the much needed versatile innovation

in the field of architectural creation after a careful study of the technological development of that period.

7.9 Economy Of Cable Structure

Much as other forces of design consideration come into play in a project execution, the economic aspect is regarded as one of the most important. Its importance lie in the space execution of a project and the decision governing the design synthesis as well. All these decisions have become cost index of a successful project need. So to this end, the architect with his design colleagues would have to decide on a concrete cost implicatory decision for a successful project execution.

This has brought into focus the need to have wide range of materials with a proper understanding of their properties such as durability, texture, maintenance, cost, fire resistance, aesthetics etc. It is this factorial judgement that would decide the project quality.

Cost analysis

The cable roofing would not be seen in isolation in determining its cost efficiency, but rather would be compared with other materials used over a period of time in the field of rooding technology. This foresight would go along way in determining cost per square metre of the material, considering its insulation and maintenance cost. This comparative cost would give a good judgement as to the aesthetic usage of cable technology. The comparison below would highlight the advantage.

The comparative cost analysis of industrial frame buil building was made by Ketchum and Konkel of the Ideolite Company in a paper presented in the World Conference on Shell structure published in 1964. The cost analysis presented looks at the advantage of cable structure used in some of the project executed by the firm.

The physical health education building of Central Washington College built on an oven of 45.73m by 119 metre was found to cost $151.15/m^2, this include the architects fees and a sale tax of 4%, it shows a reduction of 10% for the same area employing different roofing system.

The Kansas City terminal airport building employing the same concept of roofing system, had a cost of about $12163.57/m^2 including professional fees.

The above highlight shows that the roof cost effectiveness lies in understanding the constructional details involved otherwise the cost shall overide its numerous advantages.

CHAPTER EIGHT

CLIMATIC DATA

8.1 Environmental Data And Their Design Implications

The climatological data survey of the site are considered in gaining an insight into various design problems and ways they could be tackled for an efficient project execution.

The site

Ahmadu Bello University, Samaru campus is found to share the same climatic condition with Zaria which is typical of northern Nigeria. It is found out that variation in climatic condition along the region is caused by the pressure variation of the inter tropical convergence zone (ITCZ). A critical understanding of this variation would give a measure for any implicatory design decision regarding climate.

8.1.1 Winds

The site under consideration experiences rain between the month of May and October due to variation in ITCZ - moving north of the area, this period is regarded as the wet season which last for six months.

The wind direction changes towards the south west between the month of April and October, the wind is moist ladden along this period and is characterised by storm. The average wind velocity around this period is 3 m/sec. This velocity has an implicatory effects on buildings whose roofs

or openings are not properly placed. The destructive tendencies of this wind would not allow any designer to take risks.

The other prevailing wind, the north east trade wind blows across from the sahara between the months of November and April. It is characterised by its dust laddeness and dryness. Its average velocity is 2.0m sec. which gives a lot of discomfort around this period. As a measure against this wind defect , buildings should be properly oriented to avoid direct penetration into the interior. To enhance the building quality during this period, the use of fountain could be encouraged to make sure that the dust effect is cleansed by the moisture content of the fountain.

8.1.2 Temperature

The mean maximum actual temperature is recorded in the month of April with a value of 28°C. (See fig. 8.2). Between the month of January and December the temperature value drops as low as 20.5°C while between the months of July and November an average temperature of 24.5°C is recorded. This temperature variation has a great effect on the environmental as well as human factor. Adequate care should be taken in the selection of materials both for interior and exterior finishes to avoid expansion/contraction problem.

8.1.3 Humidity

The month of August records the maximum actual mean relative humidity which is 75%. This value goes as low as 12% in February and maintain an average value of 58.8%

between the month of May and November. The relative humidity a measure of moisture content in the air has the tendencies of discomfort when too low or to high. The variation of body temperature causes this discomfort. FIG 8:4

Architectural designs should also take note of this inherent problem as a measure to elemental failure.

8.14 Sunshine hours/global radiation levels

The sunshine hours fluctuation between the months of October and March is fairly constant and reasonably high (See fig. 8.1). The highest sunshine hours is recorded in the month of November with a value of 9.4, while the lowest is with a value of 5.2 recorded in the month of August. Architectural design of opening sizes should take note of the sunshine intensity of this period.

8.1.5 Rainfall

The rainy period of the site is short lived between the months of May and October. It is characterised by high intensity and storms, which generate high impact on building openings and roofs, the scope of a roof should be carefully designed to avoid leakage problem (See fig. 8:3)

The impact of rain problem has necessitated the need to have good embarkment on the site to avoid soil erosion and water logging associated with the clayish nature of the soil.

TABLE 8:1

MEAN DAILY GLOBAL RADIATION LEVELS, SAMARU

MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
MEAN GLOBAL RADIATION (cal cm^{-2}) clay 1954-80	440.6	503.6	509.0	481.0	484.0	453.6	392.6	351.0	430.6	506.6	487.0	443.6

TABLE 6.6

MEAN MONTHLY RAINFALL (mm) FOR 1928-80 & RAINDAYS PER MONTH FOR 1928-80

MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
MEAN RAINFALL (mm) 1928-80	0.2	0.9	7.1	36.2	121.1	161.6	225.7	280.4	221.4	37.0	1.2	0.1
RAIN DAYS 1928-80	0.1	0.2	0.9	3.9	10.0	12.8	16.4	20.2	16.3	4.0	0.2	0

TABLE 8.2

MEAN MONTHLY PERCENTAGE R.H LEVELS SAMARU 1954-1980

MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
A.M -	0	15.2	25.6	47.9	63.6	72.6	79.5	81.7	75.9	60.6	29.2	21.1
P.M. -	0	10.8	14.2	29.0	43.4	57.3	65.2	69.7	62.9	43.1	21.4	16.4
AVERAGE DAILY	0	13	19.9	38.45	53.5	64.95	72.85	75.7	69.4	51.85	25.3	18.75

TABLE 6.4 MEAN SUNSHINE HOURS 1954 - 1980

MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
MEAN SUNSHINE HOUR 1954-80	8.7	9.3	8.4	8.0	8.2	7.8	6.1	5.2	7.0	8.8	9.4	9.1

CLIMATIC OBSERVATIONS

TABLE 8:3

AVERAGE MAXIMUM WIND SPEED BY MONTH 1979-80 AND PREVAILING WIND DIRECTIONS

MONTHS	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVERAGE SPEED m/s	1.61	1.98	1.57	2.06	2.52	2.32	1.65	1.38	1.1	1.13	1.1	1.59
WIND DIRECTION (PREVAILING)	N.E	N.E	N.E	S.W	S.W	S.W	S.W	SW	SW	SW	N.E	N.E
WIND DIRECTION (SECONDARY)			S.W	N.E.						S.W		

TABLE 6.2

MEAN MONTHLY MAXIMUM & MINIMUM AIR TEMPS & MONTHLY MEAN RANGES SAMARU (1938-1980)

MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
MEAN MONTHLY MAX TEMP ^{o}C	30.3	32.7	35.3	35.7	32.9	36.7	28.4	27.7	29.3	31.4	31.6	30.3
MEAN MONTHLY MIN TEMP ^{o}C	13.9	16.0	19.5	21.7	21.2	19.9	19.5	19.3	19.1	17.4	15.4	13.8
MEAN MONTHLY RANGE TEMP ^{o}C	15.4	16.7	15.8	14.0	11.7	10.8	8.9	8.4	10.2	13.7	16.2	16.5

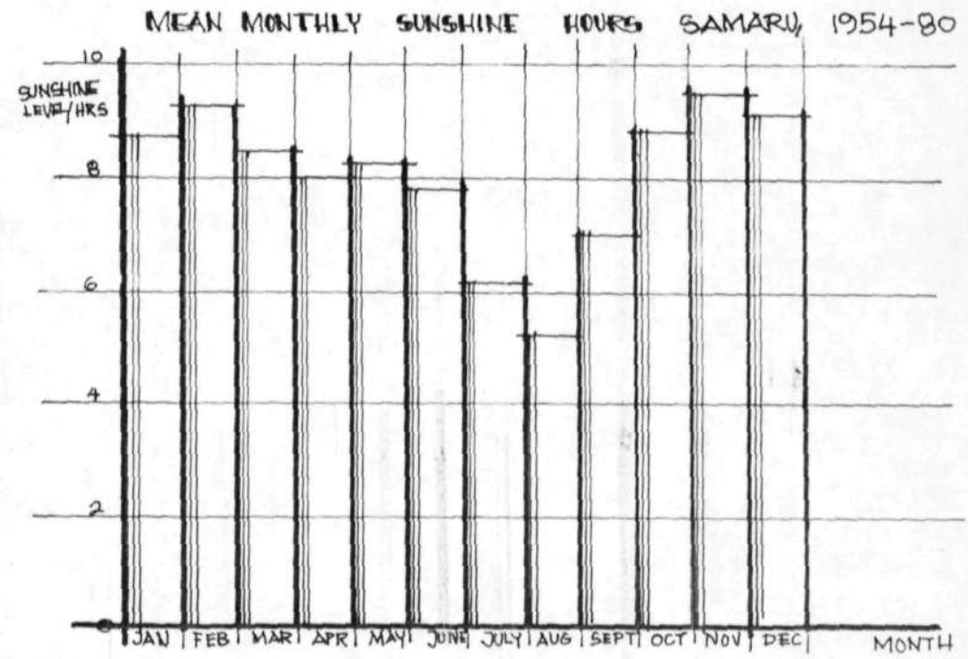

MEAN MONTHLY SUNSHINE HOURS SAMARU, 1954-80
SUNSHINE LEVEL/HRS
10
8
6
4
2
0
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTH

FIG 8:1

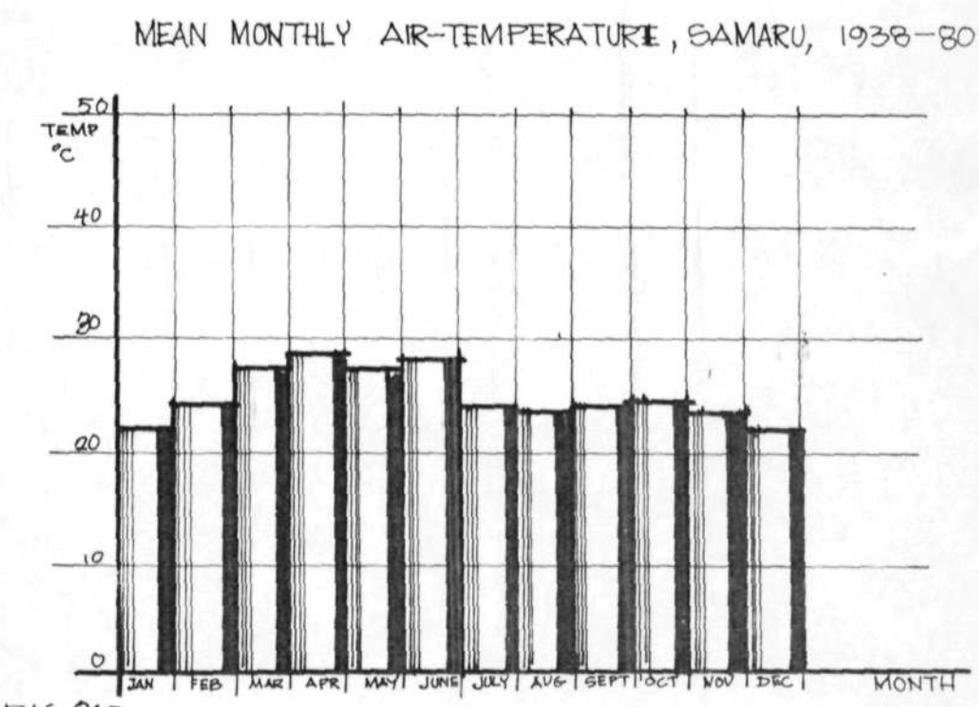

MEAN MONTHLY AIR-TEMPERATURE, SAMARU, 1938-80
TEMP °C
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTH

FIG 8:2

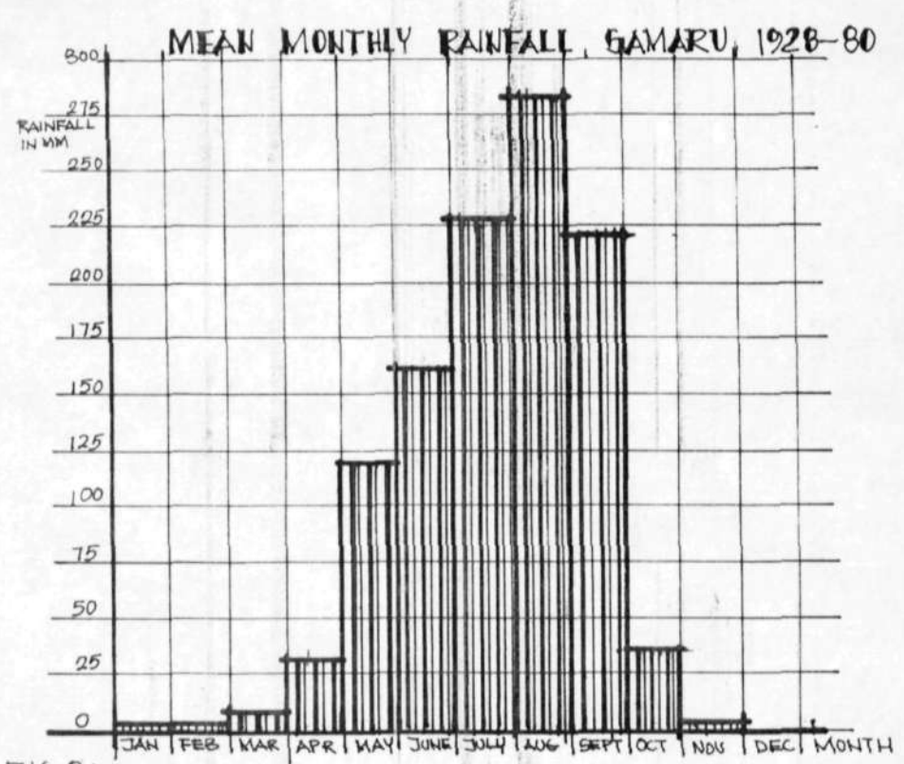

MEAN MONTHLY RAINFALL, SAMARU, 1928-80
RAINFALL IN MM
300
275
250
225
200
175
150
125
100
75
50
25
0
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTH

FIG 8:3

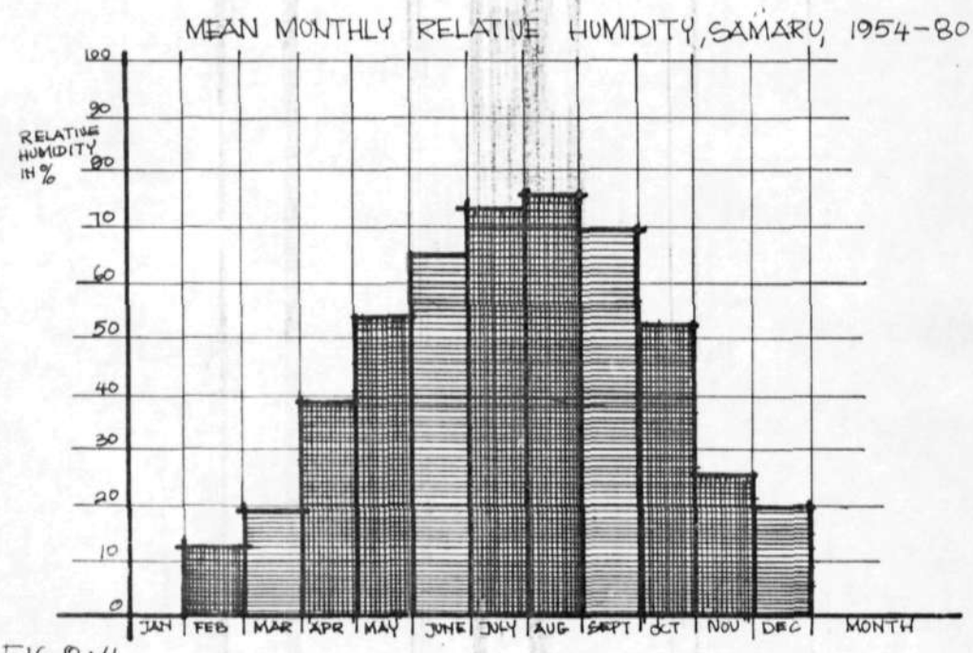

MEAN MONTHLY RELATIVE HUMIDITY, SAMARU, 1954-80
RELATIVE HUMIDITY IN %
100
90
80
70
60
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTH

FIG 8:4

Conclusion

A vivid look into all these climatological data would give a designer an insight into various design implications of any taken decision, thus good analysis of these data would help avoid these defects.

8.2 Existing Site Condition

Zaria lies on latitude $10^{\circ}11'$ and longtitude $7^{\circ}38'$ east and raised on a height of 634.9m above sea level. Because of its institutional and cultural heritage, it has been given prominence in the historical development of Hausa land in particular and Nigeria in general. The Emir is the chief custodian of the city interms of administrative functions.

Zaria city, because of its central location in Nigeria has become the point of dispasal to other regions. Its locational distribution between major towns is, Kaduna 78 km, Kano 176 km, Jos 240 km and Sokoto 387 km.

The university campus is located south west of the city, in Samaru. The university has various institutions scattered around the region: this include Kongo campus, Institute of agricultural research, ATC, Teaching Hospital etc.

8.2.1 Topography

The campus lies on an elevated level of 685 km above sea level. The campus is fairly flat around the central zone and undulate with gulleys and valley southwards towards the Kubani river.

8.2.2 Geology

The geology is similar to that of Zaria region, underlained by undifferentiated precambrian basement complex formation comprising of igneous and metamorphic rocks. The igneous rocks are mainly Biotite gneisses and older granite while metamorphic sediments include quartzites and schist found in streams and valleys. The area is overlain by alluvial laterite deposit.

8.2.3 Soil

The soil is classified as that which belongs to "Zaria Soil group" whose depth covering level is 14 feet. The soil material consist of deposited silty sand overlying sedimentary decomposed rock. The alluvial nature of the soil permits water retention and hence good for agricultural activities.

8.2.3 Vegetation

The university falls within the guinea savanna grassland with its park lands and gallery forest.

Examples of trees found around the campus are:

- Locus bean tree.
- Shear butter tree.
- Iol bean tree.
- Isobelina tree.

These trees grow to an average height of 6m with a foliage of about 15m.

Some tropical trees have been selected to be around the site as part of the project's landscape scheme. The features of these trees are given below:

(a) Neem (Azadirachta Indica)

This belongs to the mahogany family, has a densely wide spread crown, and grow to an average height of 5,3m. It attains a height of about 16m at maturity.

(b) Savannah mahogany (Khaya senegalensis)

Because of its water requirement it is best grown around the valleys and long heavy plain where water table is high.

(c) Eucalyptus (Canal dulensis)

Th.s has a vertical crown, and grows slowly for variety.

(d) Tecoma

Has yellow flowers and large leaves, and grows to a height of about 2m at maturity.

(e) Bourganivilla

This behaves as a shrub and a climber having pink and red flowers. It grows to an average height of 2m.

(f) Delomix (Flame of tse forest)

This has an average growth of 14m and a foliage of 14 metres.

SITE ANALYSIS

8.3 Site Description

The site is located in the southward part of the main campus earnmarked for the extension scheme of the existing campus facilities. Because of its potential to cater for the future needs of the campus recreational activities, various facilities, such as the auditorium, leisure complex, swimming pool complex, convocation arena, gardens and have been zoned in this area.

It is bounded on the north by the students union building on the sest by the school of general studies (proposed), on the south by the proposed housing scheme for staff (junior and senior). (See fig.).

It is envisaged that by the time the campus rose to its proposed level, the site shall form the main core of the university's cultural and recreational activities.

8.4 Site Attributes

Access

The site is accessible to pedestrians as well as vehicular user through various routes linking it to the catchment area. A dual carriage way axis passing the western part of site links it with the main campus, with primary routes connected to serve other areas.

It is expected that the main campus population shall not have distance constraint parsee, because the maximum driving time would not exceed five minutes. Eighty percent of the extension population (staff and students) reside within a walking distance of 5 minutes. (See fig.8:5).

8.4.1 Water supply

Its proximity towards the water works is of an advantage to the supply of basic water demand. The distribution network as proposed by the master plan scheme takes care of this requirement. (See fig. 8:8).

8.4.2 Electricity supply

Looking at the critical demand requirement for power consumption, the proposal scheme through the National Supply Grid has distributed power of about eleven kilowatt hour to the site. This supply would give room for development of those necessary facilities within the proposal's economy. (See fig. 8:9)

8.4.3 Sewage disposal

The site sewage disposal is expected to function with the existing sewage system located south east of the site. Expansion could be made to locate some sewage plants as population rises. FIG 8:6

8.4.4 Storm drainage

The effect of storm drainage on the site if not well tackled would create errosion, gullies and other form of land deformation looking at the loose nature of the soil. As a measure against this defect a channel line proposed by the extension scheme shall be utilized in the channelization scheme. (See fig.8:7).

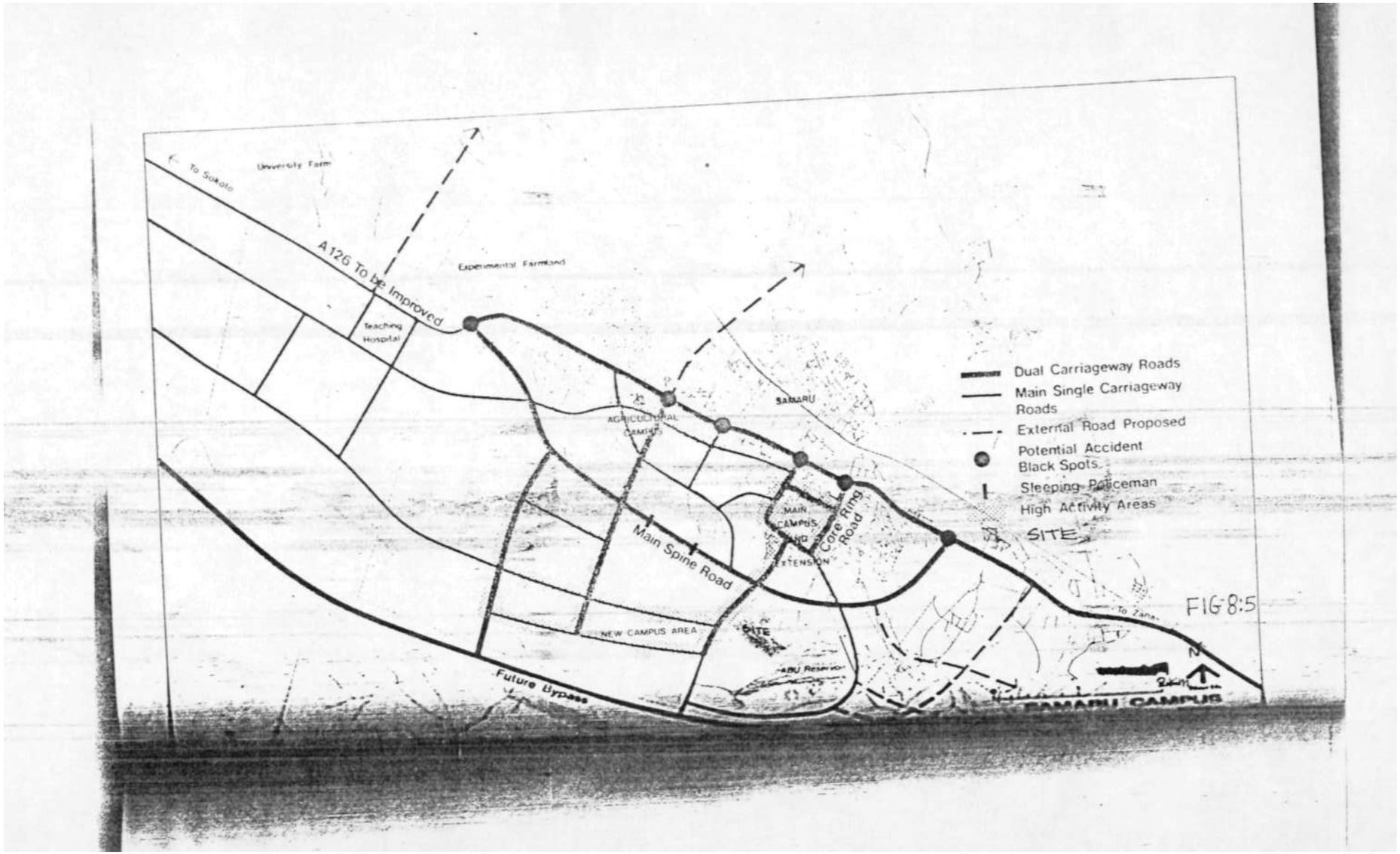

To Sokoto
University Farm
A126 To be Improved
Experimental Farmland
Teaching Hospital
AGRICULTURAL CAMPUS
SAMARU
MAIN CAMPUS EXTENSION
Core Ring Road
Main Spine Road
NEW CAMPUS AREA
SITE
ABU Reservoir
Future Bypass
To Zaria
SAMARU CAMPUS
Dual Carriageway Roads
Main Single Carriageway Roads
External Road Proposed
Potential Accident Black Spots
Sleeping Policeman
High Activity Areas
SITE
N

FIG 8:5

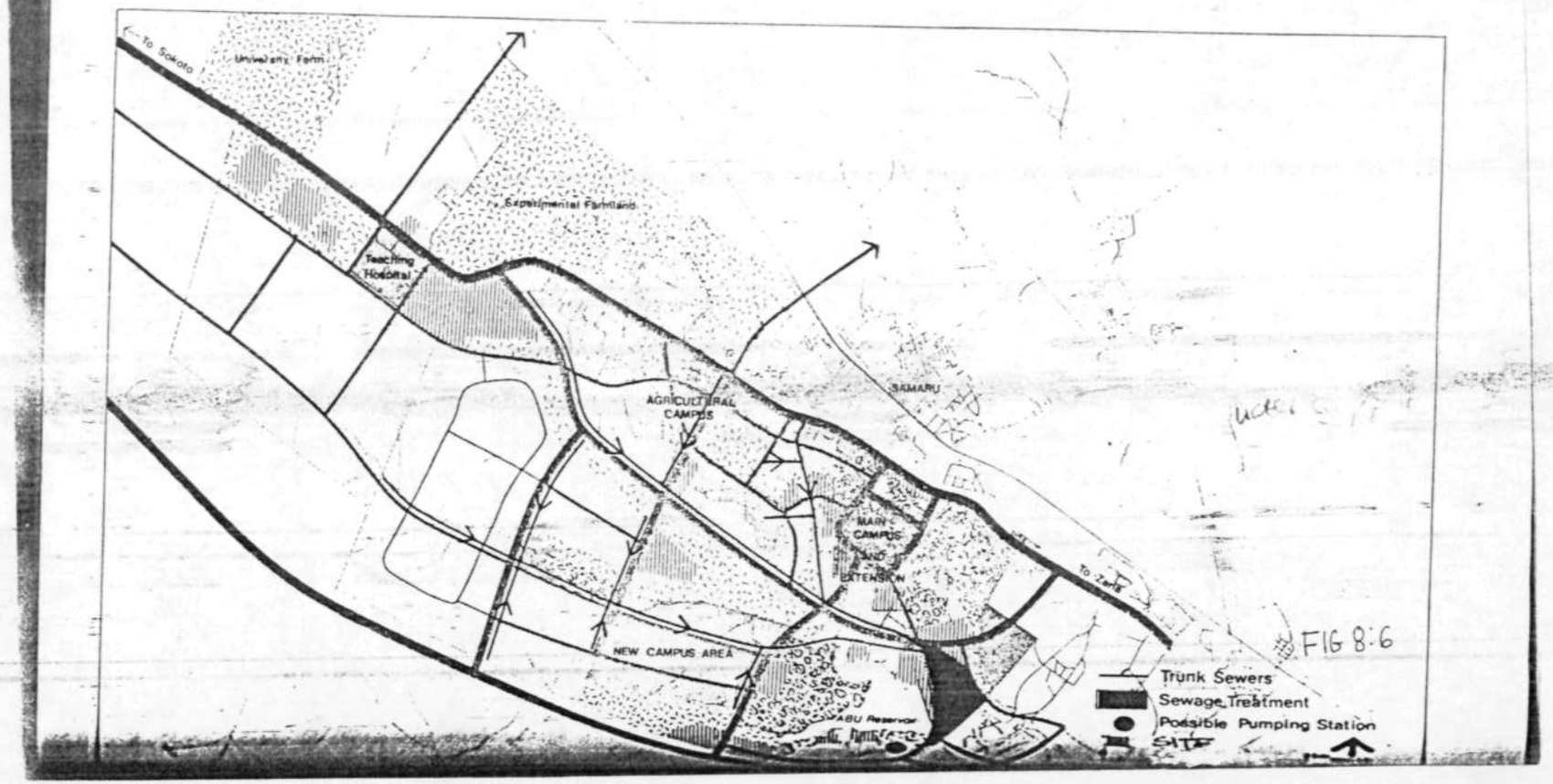
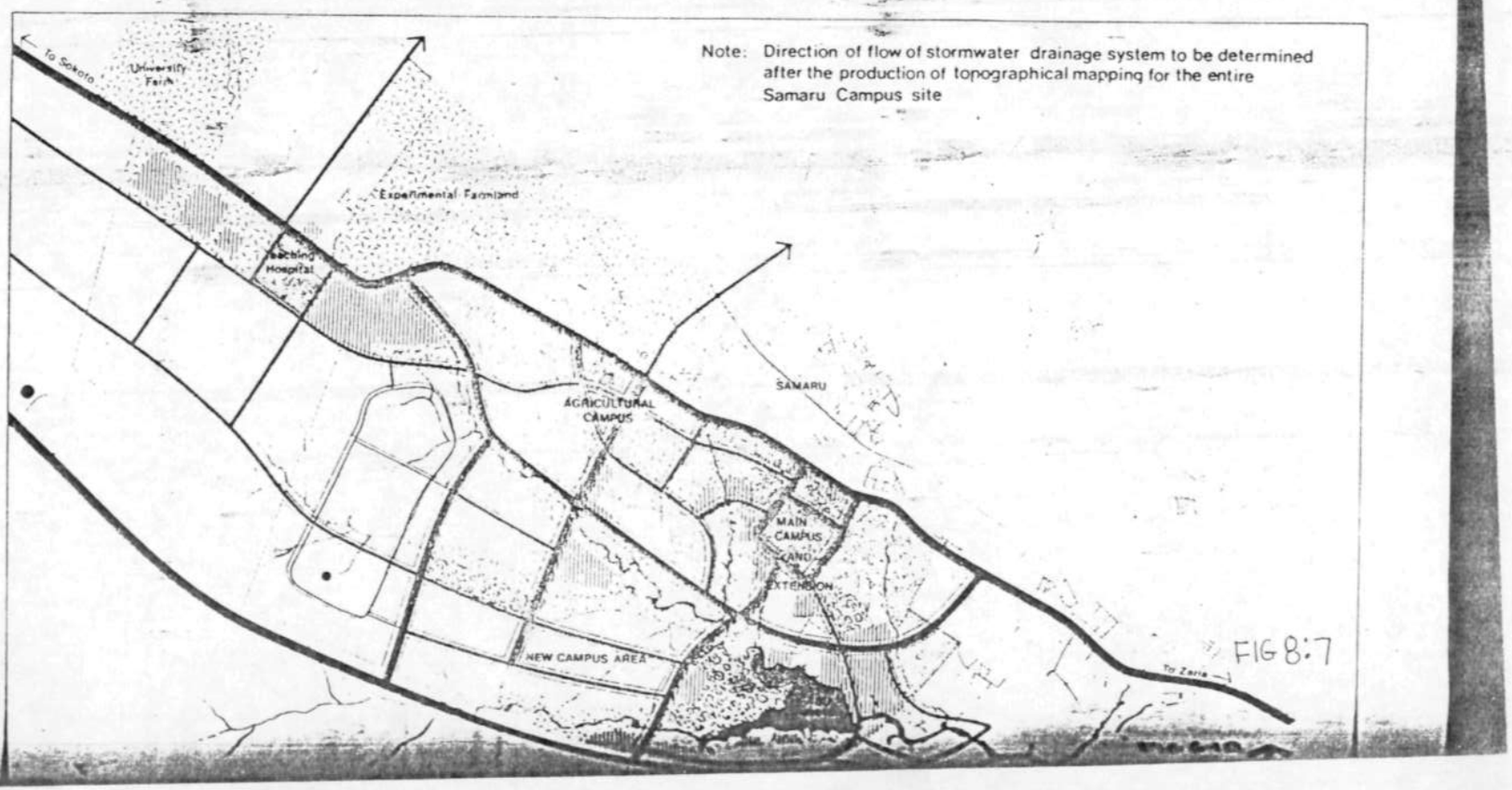
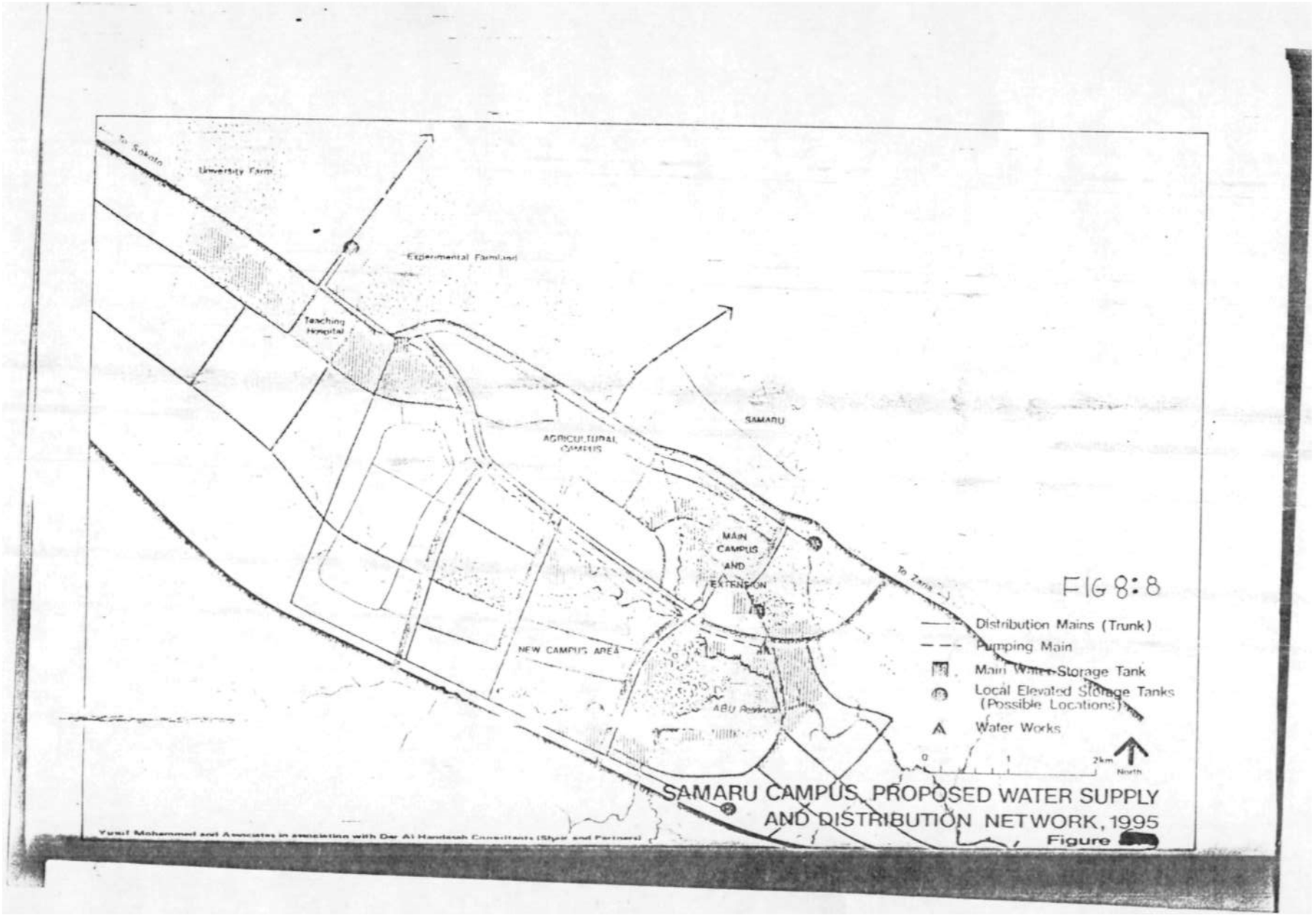
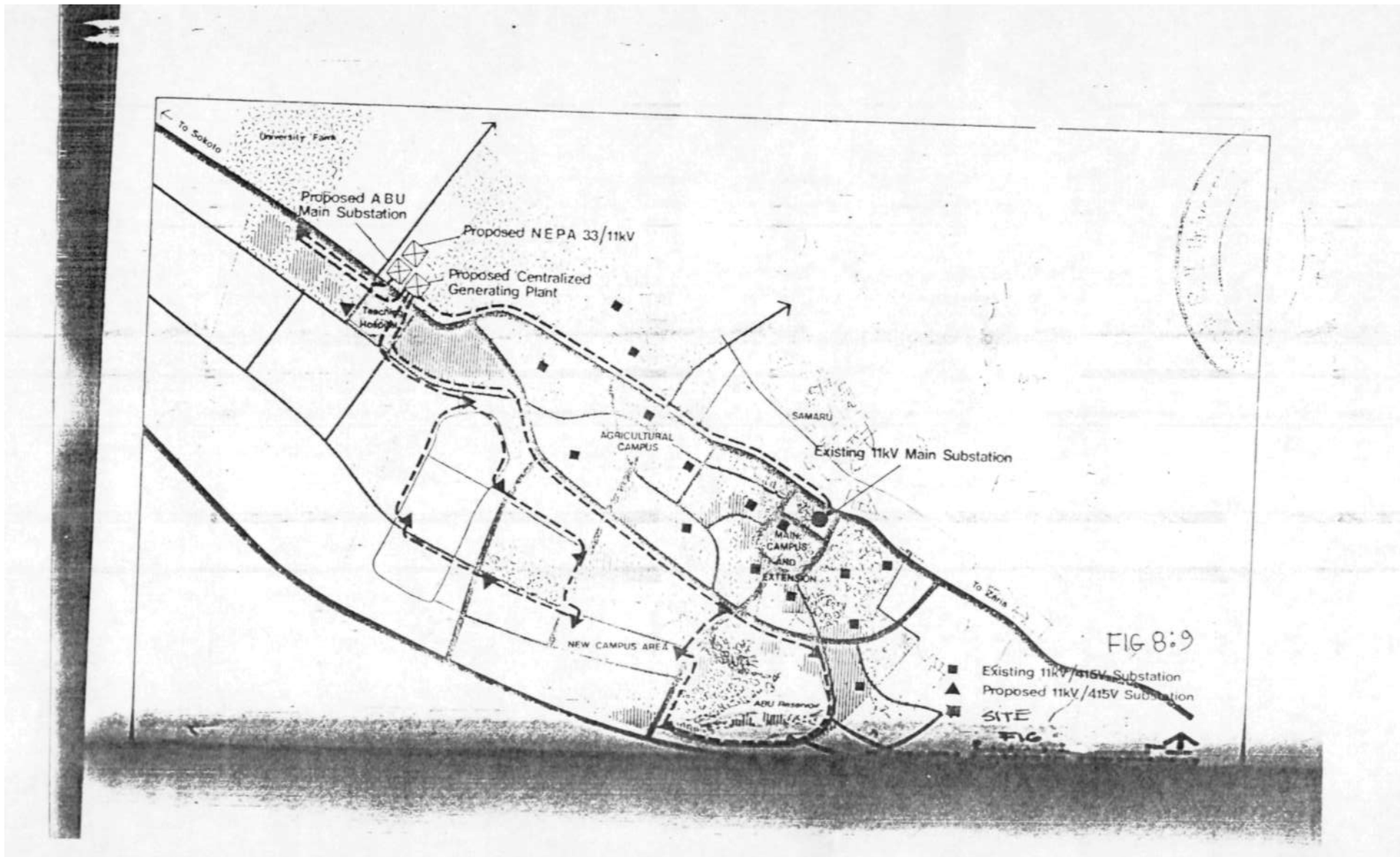

To Sokoto
University Farm
Experimental Farmland
Teaching Hospital
AGRICULTURAL CAMPUS
SAMARU
MAIN CAMPUS AND EXTENSION
To Zaria
NEW CAMPUS AREA
ABU Reservoir
Trunk Sewers
Sewage Treatment
Possible Pumping Station
SITE

FIG 8.6


Note: Direction of flow of stormwater drainage system to be determined after the production of topographical mapping for the entire Samaru Campus site
To Sokoto
University Farm
Experimental Farmland
Teaching Hospital
AGRICULTURAL CAMPUS
SAMARU
MAIN CAMPUS
LAND EXTENSION
NEW CAMPUS AREA
To Zaria
FIG 8:7


To Sokoto
University Farm
Experimental Farmland
Teaching Hospital
AGRICULTURAL CAMPUS
SAMARU
MAIN CAMPUS AND EXTENSION
To Zaria
NEW CAMPUS AREA
ABU Reservoir
FIG 8:8
Distribution Mains (Trunk)
Pumping Main
Main Water Storage Tank
Local Elevated Storage Tanks (Possible Locations)
Water Works
0
1
2km
North
SAMARU CAMPUS, PROPOSED WATER SUPPLY AND DISTRIBUTION NETWORK, 1995
Figure


To Sokoto
University Farm
Proposed ABU
Main Substation
Proposed NEPA 33/11kV
Proposed Centralized
Generating Plant
Teaching
Hospital
AGRICULTURAL
CAMPUS
SAMARU
Existing 11kV Main Substation
MAIN
CAMPUS
AND
EXTENSION
To Zaria
NEW CAMPUS AREA
ABU Reservoir
FIG 8:9
Existing 11kV/415V Substation
Proposed 11kV/415V Substation
SITE

CHAPTER NINE

FUNCTIONAL DIAGRAM

9.1 Functional Diagram And The Design Process

The diverse nature of activities in an architectural space has directed the attention of architects to bring into focus those intricate functions closer together for efficient design process. This takes the form of grouping related functions in a unit and later relating them with a set of relationship in another unit. The totality of the unification process defined the building form.

The relationship as established within the context of architectural design process takes the following three forms:

(a) Visual relationship.

(b) Vertical relationship.

(c) Linear relationship.

The scale of the design requirement permits the selection of any of these intricacies or the selection of whole working homogeneously.

9.1.1 Visual relationship

In this approach, sets of relationship are established based on visual communication. The relationship so established would highlight the demand requirement of that function. For example the orientation of hotel rooms towards a beach; the placement of a bar near a swimming pool etc. This relationship show the vibrancy of visual communication.

9.1.2 Vertical relationship

Functions are related vertically in a situation where restriction is placed on land and not on height. The relationship gives linkage through various architectural elements such as stair cases, lift, ramp etc. Visual dominance might be another factor selected for vertical relationship, this gives an elemental composition along the vertical plain which acentuate the building mass, thus harmony is achieved.

9.1.3 Linear relationship

Where land is abundant and restriction not placed on any function, linear relationship is best achieved through the manipulatory tendencies of various functional elements. Visual elegance can also be achieved by the juxtaposition of building mass along the horizontal plain.

The auditorium functions are manipulated through the use of the space concept establishment. The functional contiguity of the complex is therefore shown as follows:

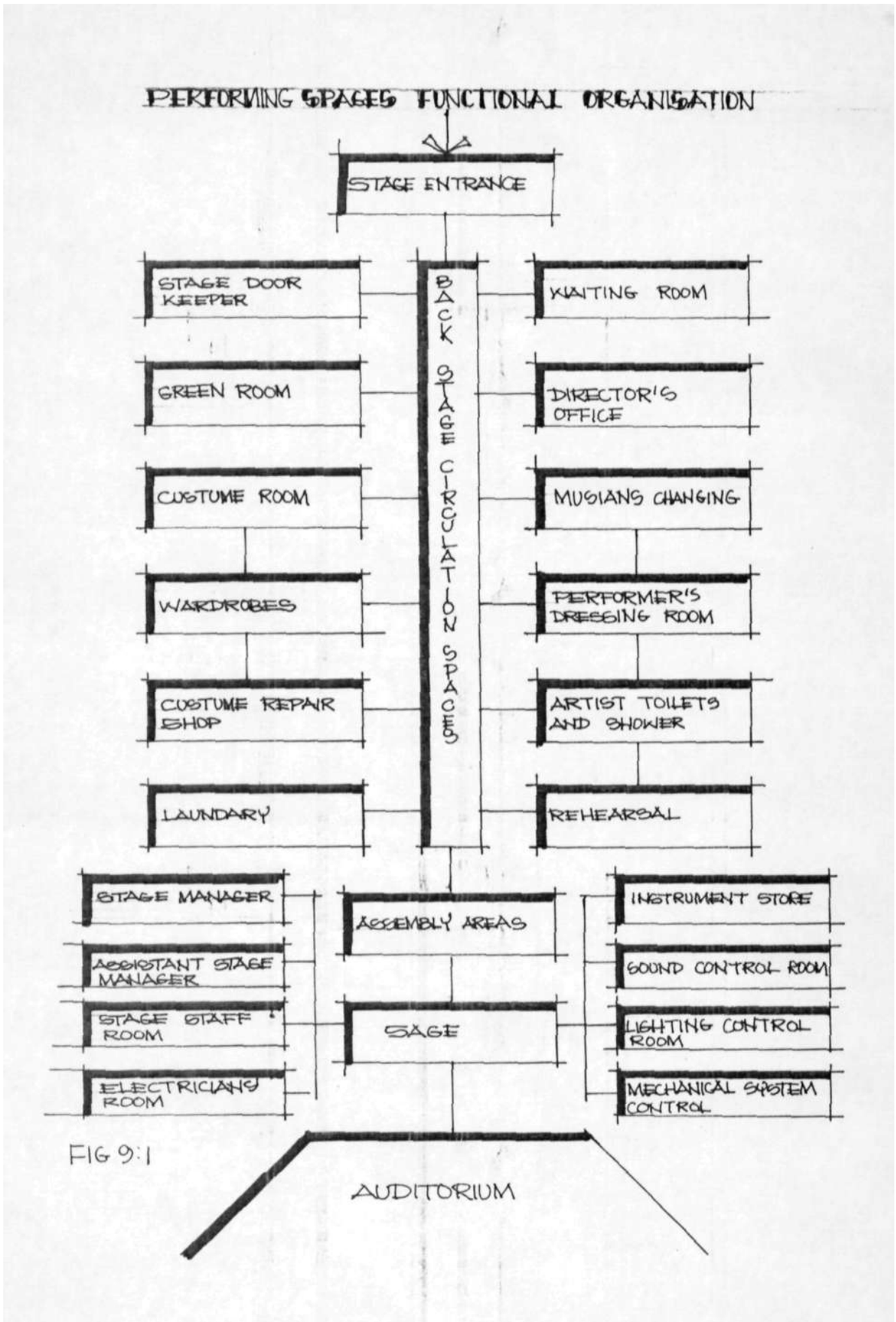

PERFORMING SPACES FUNCTIONAL ORGANISATION
STAGE ENTRANCE
STAGE DOOR KEEPER
GREEN ROOM
CUSTUME ROOM
WARDROBES
CUSTUME REPAIR SHOP
LAUNDARY
BACK STAGE CIRCULATION SPACES
WAITING ROOM
DIRECTOR'S OFFICE
MUSIANS CHANGING
PERFORMER'S DRESSING ROOM
ARTIST TOILETS AND SHOWER
REHEARSAL
STAGE MANAGER
ASSISTANT STAGE MANAGER
STAGE STAFF ROOM
ELECTRICIANS ROOM
ASSEMBLY AREAS
SAGE
INSTRUMENT STORE
SOUND CONTROL ROOM
LIGHTING CONTROL ROOM
MECHANICAL SYSTEM CONTROL
AUDITORIUM

FIG 9:1

9.2. Space Analysis And Schedule Of Accommodation

Public Space

Foyer: Area is based on the capacity of the auditorium and the peak hour demand.

Area per person = $0.45m^2$

Area for 3500 persons = 0.45×3500

= $1575m^2$

Assume 40% circulation area

∴ Fayer Area = 40% of $1575m^2$

= $630m^2$

Box Office: Area for selling tickets; to contain personnel and some furniture fittings

Area = $24m^2$

The foyer is to contain 3 box offices

∴ total area = 24×3

= $72m^2$

Control room: to serve as a check for entrants into the auditorium.

Area = $20m^2$

Number required equals 2 for the two entrances provided

Total area = 20×2

= $40m^2$

Telephone boots: To serve the communication requirement of of the audience

. rea required per one = 1.0x1.0m

Total number (4) = $1m^2$

∴ Total area = $4x1m^2$

= $4m^2$

First aid room: to serve the emergency need of the audience during shows

Area required = $12m^2$

to contain necessary gadget for operation.

Security room: To function as a measure against any vandalic act.

Area required = $12m^2$

Shopping Areas

This area is part of revenue generating source for the measurement of the complex, thus letable areas are provided on a standardised level.

This unit is to contain standard furniture and a storage unit.

Area required per unit = $54m^2$

The letable area functions are:

Tailoring	...	...	...	$54m^2$
Barbing	...	...	...	"
Insurance	...	...	...	"
Boutique	...	...	...	"
Hair Dress ng..		...	...	"

Provision store ... ... $54m^2$

Photocopying ... ... "

Magazine/Newspaper ... ... "

Post office (2 module chozen = 54x2) 100m

Banking area: A commercial institution for the monetary transaction of the community.

Customers waiting (to accommodate 50 customers at a time)

a time

Area required = 50x1.2

= $60m^2$

Banking Hall: Operation area of the banking services (to accommodate 20 workers)

Area required = $132m^2$

Strong room: Safe t monetary transaction

Area required = $9m^2$

Bank manager: the administrative head of the bank

Area required = $30m^2$

Secretary: Assistant to the bank manager

Area required = $12m^2$

Auditor: to keep audit account

Area required = $20m^2$

Accountant: to keep record account of the banking activity

Area required = $20m^2$

Refreshment zone

Bar; area for liquor consumption.

Area required = $72m^2$

Lounge; (relaxation area for a scenic effect)

Area required = $68m^2$

Dining; unit where variety of dishes are consumed

Dining Area

To sit 100 dinners

Area required = $140m^2$

Kitchen; unit for the preparation of dishes to serve dinners.

Area based on dining capacity

Assumed $\frac{1}{3}$ of dining area

Area = $45m^2$

Storage unit = $15m^2$

Catering officer= $15m^2$

Changing room = $12m^2$

Toilets = $9m^2$

Discotecque

This is the explosive social unit for dancing engagements.

Dancing ring area = $300m^2$

Sitting area = $50m^2$

Bar and storage area= $20m^2$

D. J. area = $12m^2$

Cloak rooms (2) = $12m^2$

Library

For journals, reference volumes and magazines (book store)

Reading area (to sit 50) = $114m^2$

Librarian (2) = $15m^2$

Audiovisual = $36m^2$

Storage = $12m^2$

Archives

For keeping records of theatrical activities and allied subjects

Area = $50m^2$

Conference room

For administrative meetings to sit 30 persons.

Area = $60m^2$

Interview room

For holding interviews of various kinds

Area = $30m^2$

Storage (equipment) = $15m^2$

Conference Centre

This is an academic zone for intellectual exchange of ideas. Papers are presented for debate on issues concerning human development.

Conference Hall to sit 750 persons:

Area required = $750 \times 1.2m^2$

= $900m^2$

Committee rooms (2)	=	$30m^2$
Private discussion room (2)	=	$20m^2$
Waiting room	=	$40m^2$
Exhibition space	=	$30m^2$
Receptionist	=	$20m^2$
Cloak rooms	=	$20m^2$
Toilets	=	$9m^2$

Administration

General manager; the administrative head of the complex

Area required	=	$30m^2$
Assistant manager area	=	$25m^2$
Secretary and waiting	=	$30m^2$
Accountant	=	$25m^2$
Assistant accountant	=	$25m^2$
Secretary	=	$20m^2$
Office for 2 account clerks	=	$30m^2$
General office (to sit 6)	=	$30m^2$
Coffee room	=	$9m^2$

Artistic director's office

Area + Secretary	=	$39m^2$

Two offices for assistant directos

Area	=	$30m^2$ each
Total	=	$60m^2$

Toilets for senior staff

Area	=	$12m^2$
Toilets for I & J. staff	=	$9m^2$

Productic ı Administrative Spaces

a) Director's office = $30m^2$

Secretary + waiting = $12m^2$

Total area = $42m^2$

b) Two production manager's offices

Offices = $25x2 = 50m^2$

Secretary = $12m^2$

Total area = $62m^2$

c) Designer offices (2) = $40m^2$

d) Lighting specialist office = $32m^2$

e) Acoustic specialist office = $32m^2$

Design studio (for set design and effect)

-Dark room (photographic)

-4 Design boards

-Display and instrumental platform

-Colour mixing (light)

-Set rehearsals

Total Area = $120m^2$

Performance spaces

a) Stage managers' office

Area = $32m^2$

b) Assistant stage managers' office

Area = $30m^2$

c) Mechanical system control room

Area = $30m^2$

d) Lighting control room = $30m^2$

e) Acoustic control room (to allow for material testing) = $30m^2$

Musical instrument storage = $60m^2$

Carpentary workshop = $200m^2$

Electrician (2) = $30m^2$

Rehearsal room (for 50 persons) = $200m^2$

Dressing room (for 30 persons) = $196m^2$

Paint shop = $200m^2$

General store = $60m^2$

Laundary = $40m^2$

Green room = $40m^2$

Auditorium

To sit 3500 person

Area required per seat = $.5x.85m^2$

= $.425m^2$

Area per 3500 = $1487.5m^2$

Assuming 40% circulation $595m^2$

Total Area = = $(1487.5+595)m^2$

≈ $2082.5m^2$

Stage; this is the arena for performance of theatrical activities.

Standard allowed 0.46-0.65/seat

Chosen area = $0.5m^2$

Total area = 0.5x3500

= 1750

Assume size of the stage is taken as 10% of 1750 = $175m^2$

Amphitheatre

This is an outdoor performing theatre designed to accommodate the African theatrical arts.

Foyer	=	$100m^2$
Box offices (3)	=	$36m^2$
Control rooms (2)	=	$24m^2$
Magazine shops (6)	=	$54m^2$
First aid (2)	=	$24m^2$
Bar area	=	$60m^2$

Arena seating to accommodate 4500

Area per person = $.45m^2$

Total area required = $2025m^2$

Toilets

Ratio of standard taken between toilets and audience is 1 to 2500 toilet/audience respectively.

∴ No of toilets for the population

$$= \frac{4500}{250}$$

$$= 18$$

ADMIN SPACES FUNCTIONAL ORGANISATION

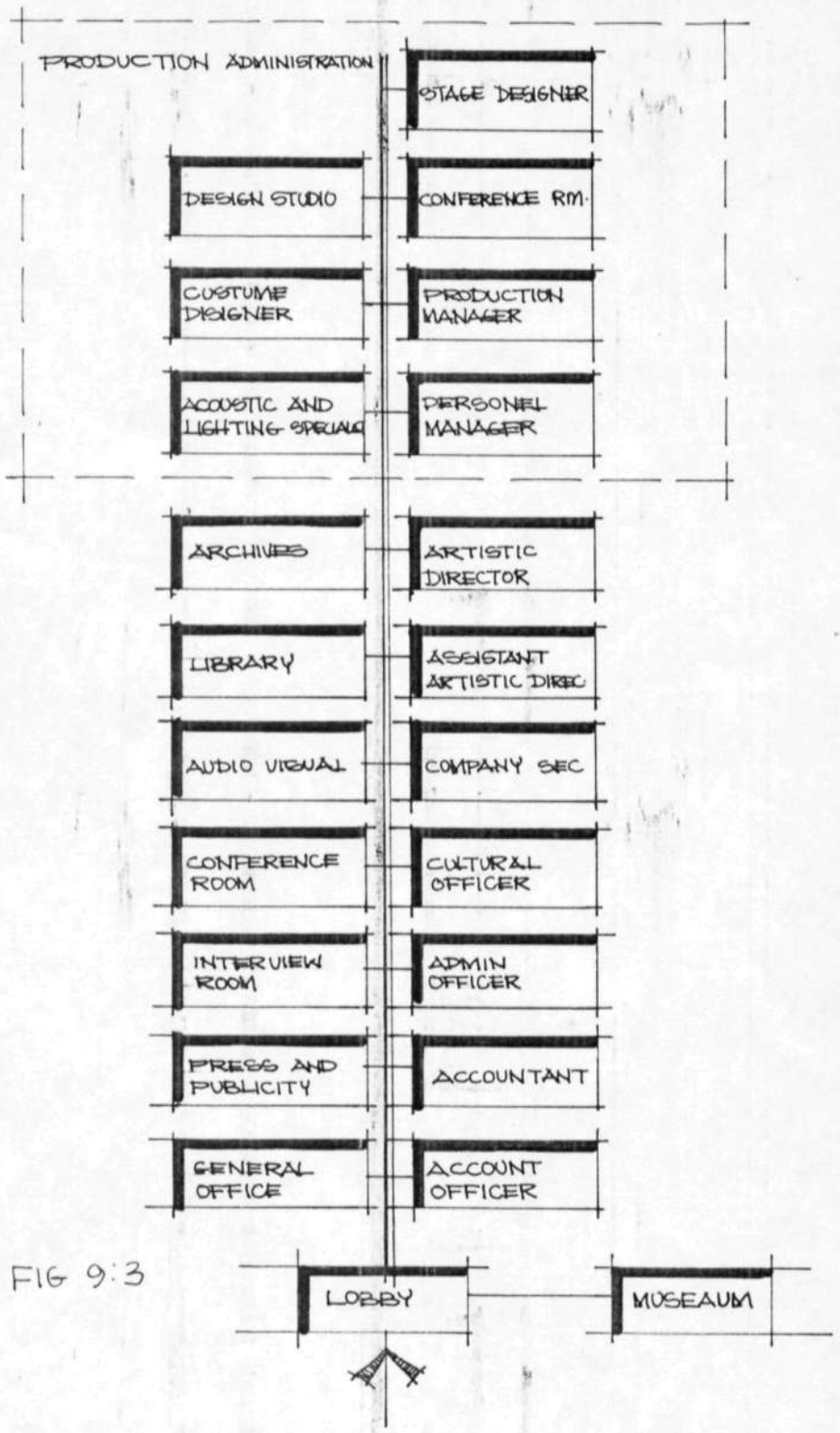


FIG 9.3

INTEGRATED FUNCTIONAL .DIAGRAM

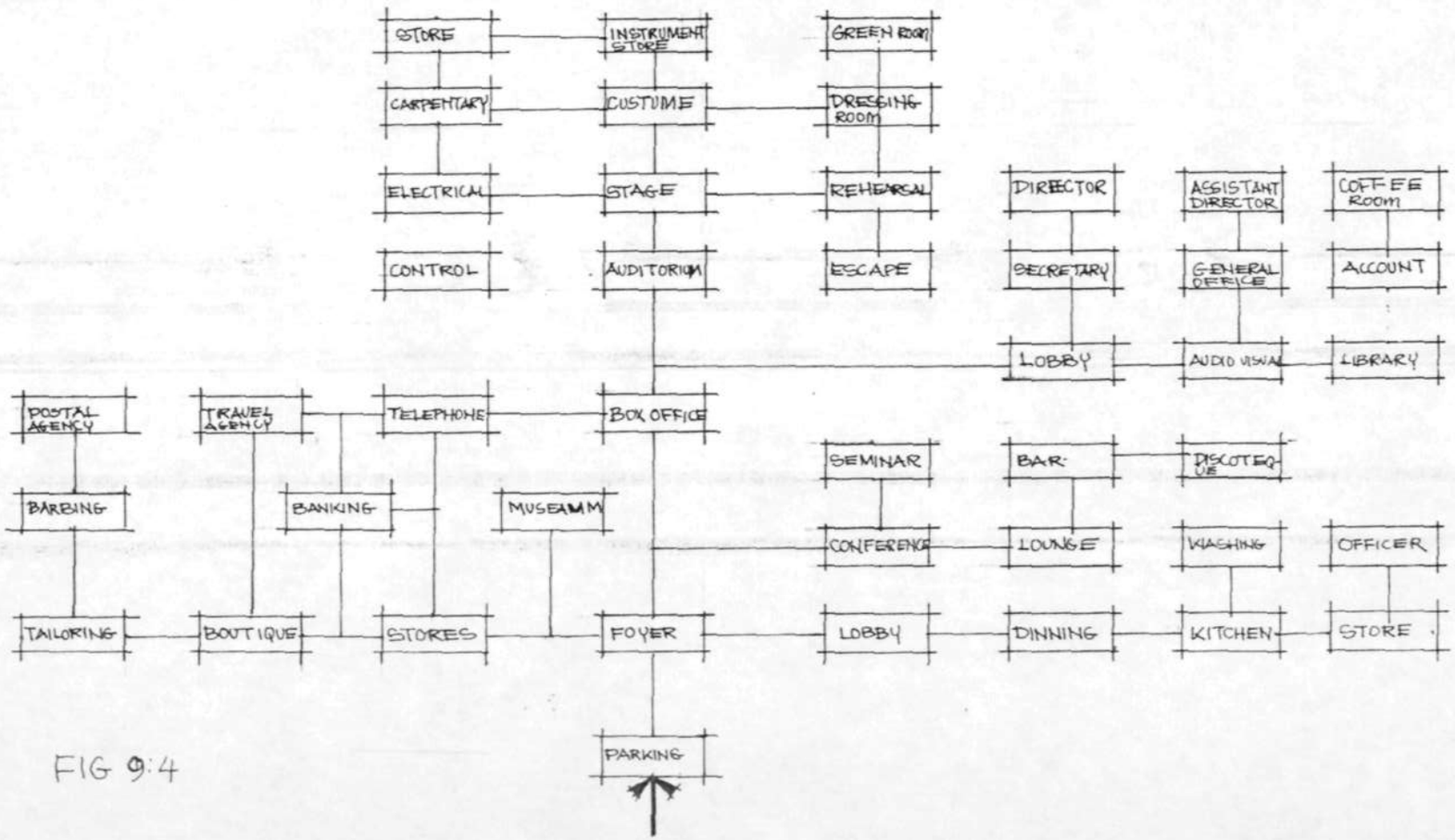


FIG 9.4

Parking spaces

Audience parking ration taken = 1 to 50

Total parking area = $\frac{4500}{50}$

= 90 spaces

Parking spaces for the main auditorium

Number of spaces = 130

To give room for activities upsurge

Museum

The cultural wing of the complex, which contain the exhibition space of artifacts for public learning.

Exhibition space: This is designed in form of gallery for public easement.

Area required = $420m^2$

designed in 4 levels to accommodate public circulation.

Curator = $30m^2$

terxodermist = $25m^2$

Storage = $60m^2$

Research room = $60m^2$

9.3. Evaluation Of Goals And Objectives

As earlier stated in the introductory part of the report on the aims and objectives of the project, it became necessary that an evaluation of this statement definition

would guide in achieving the set out goals. A broader look at these problems would once suffice to show their adaptability within the project's need.

Goals and Objectives

a) To design an auditorium with a capacity of 3500. The question asked is, have all the design requirements necessary for the satisfaction of this requirement been met? This problem include the sightline, acoustic seating, structure, etc. If no, then what are the problems. This and other questions were asked to achieve the set out capacity.

b) To apply cable structure as the roofing mast; to achieve this aim the research problem definition of the use of cable was sought. This looks at form, structure, economy, wind action vibration and stability. A critical look into this cable problem would help the designer achieve his setout goals.

c) To see how form configuration would increase the acoustical performance of the auditorium; various implicatory forms were analysed to see their defects in the acoustical performance of the auditorium. The understanding of these forms gives a good selection criteria for a functional acoustical material. This analysis has become the basic paradigm thought for room acoustics.

d) Integration of building form with the landscape; for the building site harmony various approaches were considered

in other to justify the choice of a particular decision. This looks at those landscape elements creating rythm with the building elements, thus, law of contrast and harmony is used to enhance the building site aethetics.

e) Behaviour pattern of the users towards the building form: The question asked within the design scope were the extent to which the design decision had helped in enhancing environmental behavioral pattern and also the site aesthetic. If not, then what are the constraints factors considered. This and other questions generated as use design language would clear the inherent design ambiguity.

f) Conflict between pedestrians and vehicular circulation around the site: For a good site organisation of a multi-use facilities, the problem of circulation generated by its users would have to be understood in other to show how these conflicting elements could be resolved. A further look into this tries to understand their pattern, their number with a view of creating an effective bifocating system.

This evaluation technique has given the project its right approach in the planning processes.

9.4. Design Criteria

After a careful study of the building functions and their performance on the site, it became possible that certain design criteria should be used to enhance the

building functional quality. To enhance the cunctional quality, some non exhaustive criteria were established.in the functional setting of the building. These qualities as functional as they are, are listed below, to help see their qualities:

(a) Function.
(b) Circulation.
(c) Structure.
(d) Materials.
(e) Landscaping.
(f) Aesthethic.
(g) Parking.
(h) Fire harzard.
(i) Health.
(j) Behaviour.
(k) Adaptability.
(l) Economy.

9.4.1 Function

As a design criteria the functional intricacies of the auditorium complex was studied to see the best space adjacency and their implications. Based on users requirements, the placement of these facilities would give the flexibility to be achieved.

9.4.2 Circulation

Looking at certisfaction of various function, the design tries to address itself to those inherent circulation problems.

Forces of conflict were carefully studied and grouped to give a good circulation pattern within the complex.

9.4.3 Structure

The generative question within this space was the implication of structural decisions. This question tries to look at resources available at the design disposal.

9.4.4 Materials

Well selected materials for both the interior and exterior finishes would enhance the use pattern of the interior. A careful thought should be made to see their type and their performance within the aesthetic requirement.

9.4.5 Landscaping

The best approach to the site landscaping was sought to see where and how these elements would be placed. The type of elements used was also viewed. These include: the fountain sculptures, seating, embarkment, pools and terracing. All these elements viewed together would give the complex the desired environmental quality.

9.4.6 Aesthetic

The aesthetic consideration has become so complex that the designer has to define it within his own framework. The generation of elemental building rythm, the harmony of building mass, the juxtaposition of basic function, the integration of building function, and some other intricate

thoughts are considered in the generation of aesthetic language.

9.4.7 Parking

The parking consideration tries to find out the number of possible parking spaces within the complex and also understand their use pattern.

9.4.8 Fire hazard

The nature of the building complex has necessitated the need to provide safety devices for lives and properties. To this end, measures were taken in the design to make sure that number exists, their location, their sizes do not violate the planning standard. This factor is seen as one of the most important in the project execution.

9.4.9 Health

This looks at the spartial organisation of spaces to see their implicatory effects on the available resources. Zoning concept as a measure would reduce this problem.

9.4.10 Behaviour

The behavioural approach of this design tries to look at functions as they are against their use values with a view of making adjustment in their use pattern.

9.4.11 Adaptability

Demand requirement of the user which is seen as a consonant of change is carefully studied to see that facilities required in the distant future are made to work in harmony with the existing ones.

9.4.12 Expansion

Within the site constraints, availability of space would help in creating good expansion scheme. This shall be weighed against the users demand requirements and resources available.

9.4.13 Economy

The economy of the project was considered to see those elemental components within the design requirement that are cost inductive. Measure on these elemental components would help reduce the projects cost.

9.5 Site Planning Scheme

The approach taken for the site planning was a survey of the existing dispensation in other to draw a harmony with the concept proposal. After understanding the problems inherent on the site, it became petinent that certain features would have to be adjusted or modified to suit the scheme design.

The conceptual problem planning looked at the following design parameters in the execution of the project. these are:

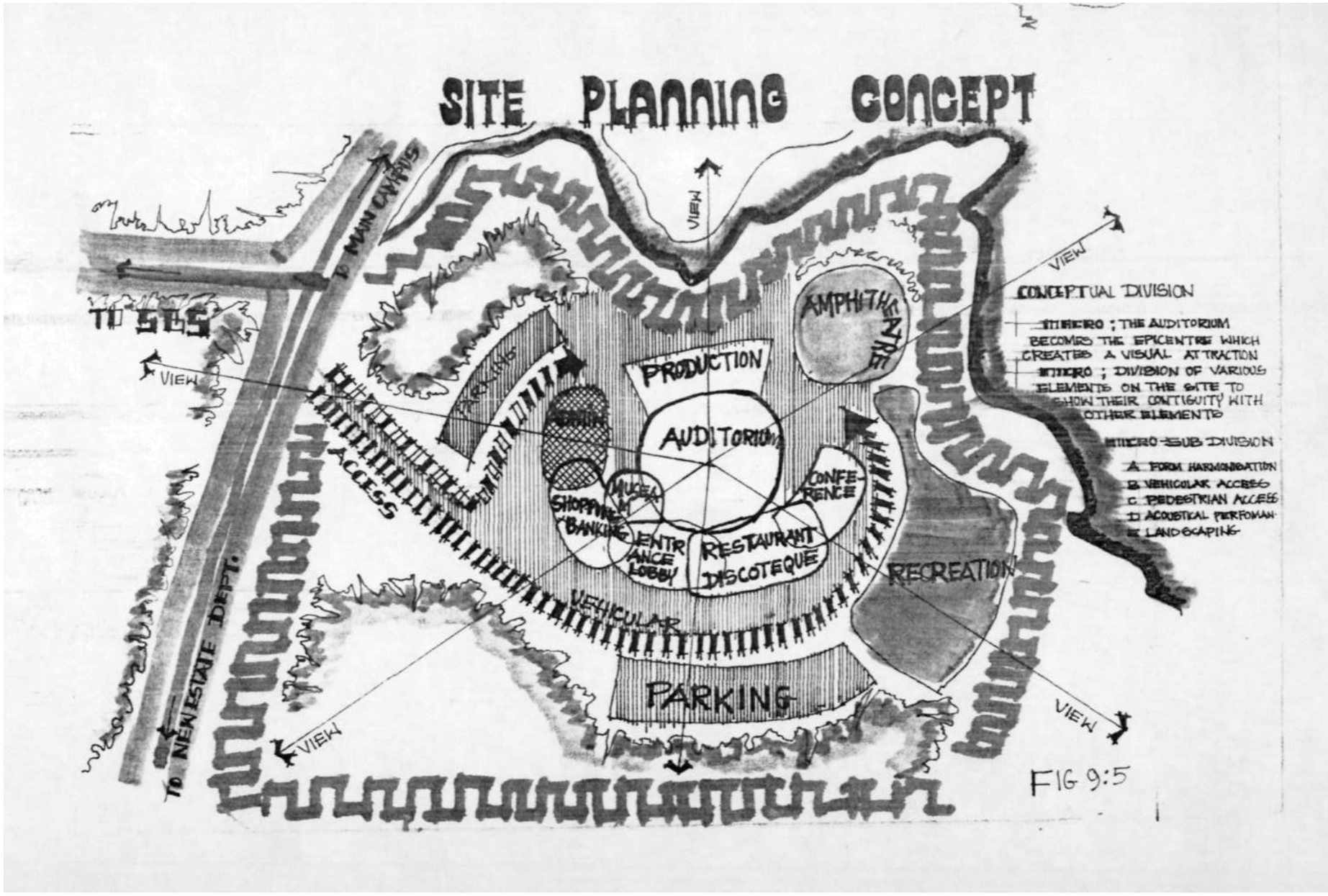

SITE PLANNING CONCEPT
TO MAIN CAMPUS
TO SES
TO NEW STATE DEPT.
VIEW
VIEW
VIEW
VIEW
VIEW
ACCESS
PRODUCTION
AUDITORIUM
AMPHITHEATRE
SHOPPING BANKING
MUSEUM
CONFE-RENCE
ENTR ANCE LOBBY
RESTAURANT DISCOTEQUE
RECREATION
VEHICULAR
PARKING
CONCEPTUAL DIVISION
MACRO ; THE AUDITORIUM BECOMES THE EPICENTRE WHICH CREATES A VISUAL ATTRACTION
MICRO ; DIVISION OF VARIOUS ELEMENTS ON THE SITE TO SHOW THEIR CONTIGUITY WITH OTHER ELEMENTS
MICRO-SUB DIVISION
A FORM HARMONISATION
B VEHICULAR ACCESS
C PEDESTRIAN ACCESS
D ACOUSTICAL PERFORMAN
E LANDSCAPING

FIG 9:5

(a) General building masses.

(b) Circulation (vehicular and pedestrians).

(c) Parking.

(d) Open spaces.

(e) Special facilities.

In essence all these spartial functions were directed towards and effective site planning scheme.

For a further development of the scheme, the following factors were considered:

9.5.1 Structures

Under this structural consideration various factors for its layout featured, these are:

(i) Location: Where should the structural elements feature looking at the planning pattern of the proposal.

(ii) Shape: The shape to be adopted looking at the available resources at the designer's proposal. So a good functional shape was harmonised with the elements at hand.

(iii) Size: In order to humanise the structure, appropriate scales were evolved to eliminate gasprophobism.

(iv) Arrangement: The arrangement of site element having a good working relationship with other elements was considered.

(v) Grouping: Within the context of design requirement, arrangement was made as to grouping of various facilities and their effect on the environmental aesthetics.

9.5.2 Circulation

In planning scheme, various categories of users were identified both pedestrians and vehicular. Area of conflict between these two users was resolved by creating a biforcation concept where plant elements were used to direct every user to the designed facilities.

9.5.3 Utilization

The site utilities such as power, drainage, water supply, sewage disposal were carefully planned within the building layout in order to give a higher efficiency. Appropriate grandient was taken for the water supply, drainage (both surface and waste) and also the sewage disposal. The high performance of these services enhances the scheme.

9.5.4 Recreation

The recreational facilities both indoor and outdoor were made to be in harmony in order to create high utility rate. There was also the cognisance of those inherent problems such as noise, and disorganisation etc. A careful placement of these functions with resilient ones reduces these defects.

9.5.5 Parking

A parking standard was used to determine the number fof population that require parking facilities within the complex. These values arrived at was adjusted to suit local demand need. The major division made in the parking provision was in the categorilisation of the users. The users identified were the public, the administrators and production artists zone. The ratio of parking space allocation amongst these competing users was 75%:10%:5%, public, administrators and artists respectively. In order to avoid delays these parking spaces were located close to their service area.

Graded tar is expected to be used as the parking floor finishing.

9.5.6 Planting

In order to enhance the environmental quality of the site, a pocket concept of planting was adopted. This concept tries to arrange landscape features in pocket form around the open spaces of the complex. Pedestrian passage ways were made between pockets in order to appreciate the enviromental structures harmony.

Decidious trees were planted around the complex in order to increase the resistance of the soil to erosion.

9.5.7 Lighting

The lighting system adopted on the site gives room for all night activity patronisation.

9.6

9.6 Conceptual Approach

The conceptual approach came through a search for a complex thoughts to solve problems inherent in the design foreseen. These problems as thought of are in an intricate relationship, so a method was adopted to see how these conflicts could be resolved. This method takes the form of searching for ideas in literary text to see how such similar project problems were solved. The understanding of thought process resolved in the case studies gave the architect the fundamental solution to the design.

In order to expand the scope of the problem definition, the following factors were considered.

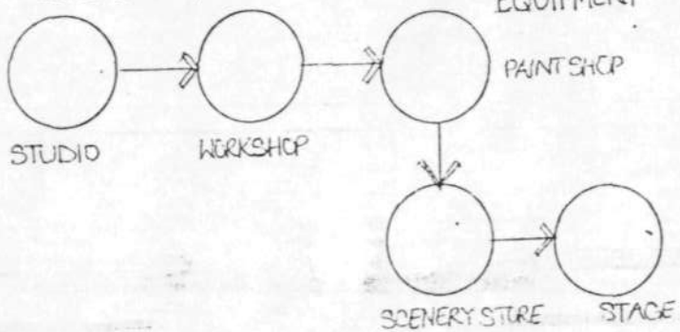
(a) The ideas to be developed and expand in full details.
(b) Perception of form based on problem analysis.
(c) The synthetic approach towards developing the project principal issues.
(d) The morphology of the design.

This basic definition as was considered in the design has tried to show the understanding of processes involved in translating non-physical problem statement into physical building product. Also in the problem solution the following factors were considered, their type and their form to give a systematic solution process. Multiple concepts were evolved at the later stage of the design to see how they could fit into the situation.

UNCOVERING AND TESTING CONCEPTS IN TERMS OF:-

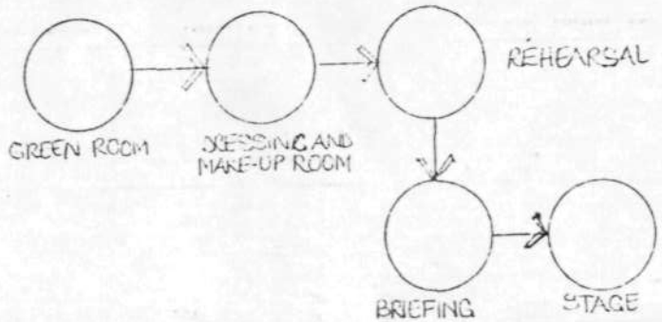
1. SEQUENTIAL FLOW

A. SCENERY



*THIS IS TO BE CONCEPTUALISED IN NON PUBLIC AREAS IN THE MOVEMENT OF PERSONNEL AND EQUIPMENT

B. PERFORMERS



2. SEPARATED FLOW

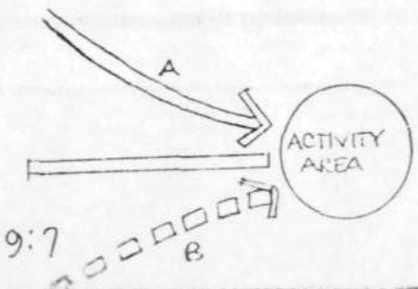
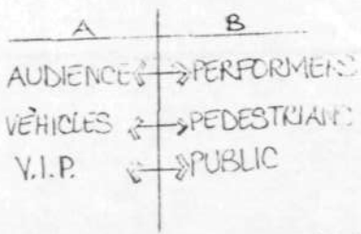
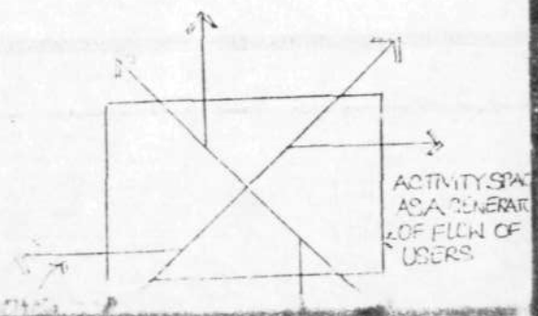


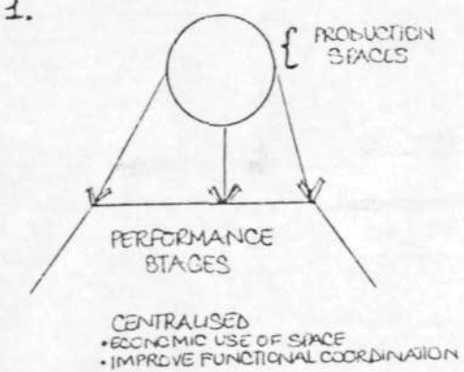
FIG 9:7

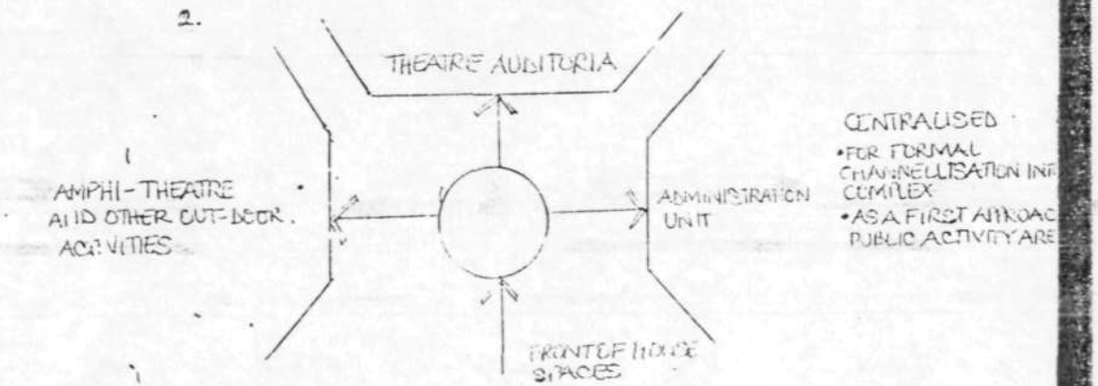


3. MIXED FLOW



UNCOVERING AND TESTING CONCEPTS INTERMS OF SERVICE GROUPING





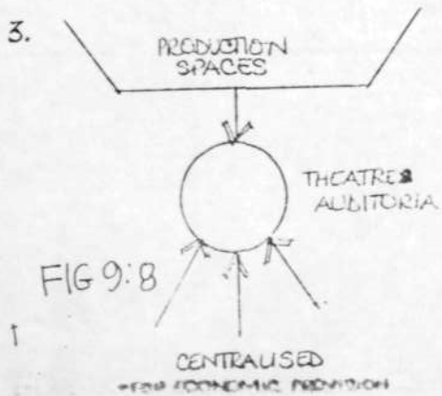
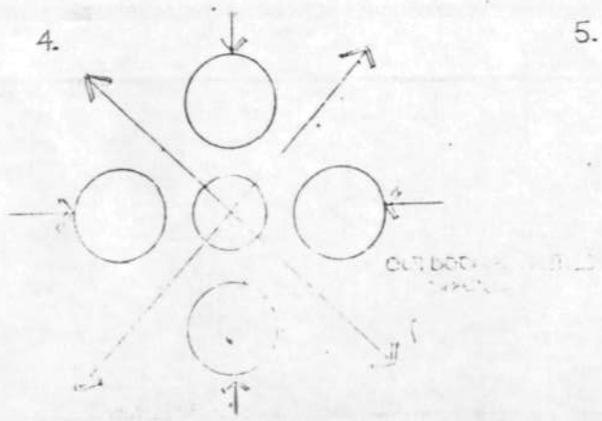
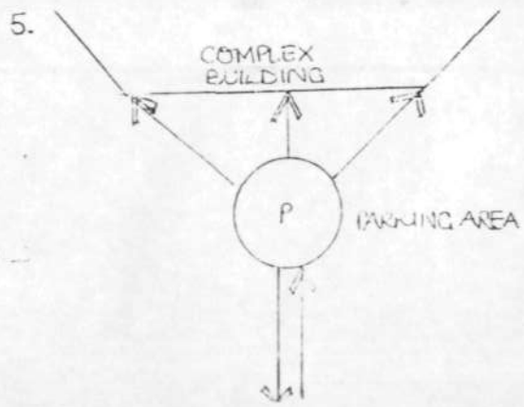


FIG 9:8





9.7 Design Concept

The multi-functional nature of the auditorium has given the designer the challenge to solve those inherent problems likely to cause a drawback in the design goals and objectives. To tackle these problems, criteria were set out to direct the project scheme into a physical reality.

The following problem factors were considered in the concept evolvement. These are:

(a) Function (volume required by activities).
(b) Geometry (circulation form and image).
(c) Context (site and climate).
(d) Enclosure (structure, enclosure planes and openings).
(e) System (mechanical, electrical etc.).
(f) Economy (maintenance cost etc.).
(g) Human factor (perception, behaviour).

9.7.1 Function

In the functional relationship of the auditorium, the adjacency of the public zone (comprising the foyer, restaurant, conference rooms, museum, shopping units) were linked with the main auditorium for a better compact planning. Within these units, the circulation pattern taking into account the economic implication of excess spaces (dead spaces) was viewed. The performing area, comprising the stage and its workshop was also co-ordinated. Efficiency of this co-ordination was based on some intricate concepts such as views, acoustic,

circulation and security. The establishment of this other gave the unit its closeness.

9.7.2 Geometry

The form selected in the complex planning was based on the performance of the intricate functions enclosed within it. The structural system used was also deterministic in itself. For visual apprehension of building masses, the auditorium with its intricate functions and complex roofing system was placed at the centre of the complex, while the production, the administration, the foyer and other functions were juxtaposed around it in a manner that harmony is achieved. The translation of this geometry came both in plan and the cubical form. The integration of this complex composition within the site enhances the site harmony.

9.7.3 Circulation

Circulation within and around the complex has given the designer the avenue to classify the circulation system. The identified circulation pattern around the site are the vehicular and the pedestrians. A system of bifocation was developed to see how conflicting use pattefn could be resolved, and also see the best planning adopted.

Various established circulation concept patterns were analysed with the projects circulation problem. This include, the ring concept, peak concept, star concept, axis concept, line concept, constellation, checker etc. This comparison

gave only an insight but does not become binding because of problem differentiation (site, climate, economy etc.).

9.7.4 Context

The contextual problem looks at the site in size and its climatic forces in order to approach the site within the limit of its forces.

The site located on the expansion reserved land covers an area of 300m x 300m which suggest that activities should fall within this area, the layout of the site scheme with the proposed functions gave an actual image of the site abundance. The survey shows that the auditorium complex covers an area of 100 x 50m, giving a reserved difference for expansion.

In the conceptualization of the building masses, a careful thought was made towards the orientation for a maximum air circulation, sun shading, humidity etc. Openings along the north east are avoided as much as possible, if demanded, elemental obstacles are provided to reduce its nuisance.

9.7.5 Enclosure

The enclosure concept tries to see how the building masses are composed whether opened or closed. The choice of enclosure depends on the type of expression that is to be expressed e.g solid, planes, voids etc. In most cases the design philosophy of the designer becomes dominant of this concept.

9.7.6 System

The services to be incorporated into the structure were carefully analysed to see their types, location and economy of such services. The judgement in this field gave the compactness of the services concept.

9.7.7 Economy

Right from the project execution stage, various design decisions were analysed to see their cost implication within the design resources. Specialist advice on various components of the complex was received and digested, in order to reinforce the efficiency of designer's decisions.

9.7.8 Human factor

The human factor on the complex is seen from the perceptive point of element used within the auditorium complex. This goes from the building mass, elements used, finishes and their type, spaces, depth and landscape etc. All these factors considered as one gave the choice of making the best design decision.

The adoption of the best concept was based on the extent to which the basic design problems were solved. This conceptual approach has given the designer room to discover those facgs outside his thought before the design stage which can channel him into a new horizon of space perception and conception.

9.8 Design Report

The design report is a review of the set out goals and objectives within the design scope. After the generation complex thoughts, analysis of complex thoughts and the establishment of complex thoughts, it became necessary to evaluate the product of the set out objectives. In this design, the extent to which the problems were solved gave it its quality.

A sequence of the problem definition used as design guide are therefore listed and discussed in detail. The understanding of the precinct detail used would generate new thoughts into the field of architecture. The parameters used for the project design are:

(a) Access
(b) Circulation
(c) Entrance
(d) Structure
(e) Orientation
(f) Lighting
(g) Acoustics
(h) Finishes
(i) Drainage
(j) Landscaping
(k) Parking
(l) Water supply
(Electricity supply.

9.8.1 Access

The access to the complex is through the dual carriage way linking the existing campus area and the proposed campus area. The dual carriage way passing along the site is connected to the proposed expressway linking Zaria and Sokoto. The site has a good linkage with major facilities around it (See fig.

9.8.2 Site plan

A ring road concept was planned for the site where a activities are suspended at the centre. This ring concept was carefully planned to resolve the conflict inherent between the pedestrians and vehicular users. The building mass was made to fit into the site through the landscape concept adopted.

Trees, landscape elements, drainage line, terrace, street light were carefully planned in contiguity with structure.

9.8.3 Circulation

The circulation pattern around the site were carefully justaposed to create high use efficiency.

9.8.4 Entrance

The entrance into the complex was elaborately decorated, using various Nigerian art forms. A fountain with a sculpture piece was located at the entrance because of its receptive nature. A gentle slope ramp for easy access both for disabled and normal people was employed. The entrance zone contains the interior lobby where rate of activity is high. The floor and the ceiling planes were also decorated.

9.8.5 Structure

In dealing with the building stability, a closer look at the structural system used would explain the basic idea incorporated. Simple frame construction was used for the public zone comprising the restaurant, shopping, admin and the museum The efficiency of this frame used is the flexibility incorporated into the system at a higher level.

The auditorium roofing because of its special attention in the project research was given prominence. It spans a length of 50m by 40m breath. The main structural supports used were the flytower and some columns located at the rear end of the auditorium. The spine support system was adopted after a careful consideration of the aesthetical balance required. The spine cable was suspended from the rear end of the auditorium to the flytower element. This spine cable covers the longest side of the auditorium (50m in length). This cable was connected to the rear beam by means of a special technique where by the cables are welded to a ring plate and cast into a ring beam. This same technique was used at the flytower end. Pheripheral catenary tie beam was made to tie the structure together, thereby increasing rigidity. To cover the auditorium space, minor cables were suspended from the spine cable and fixed to the catenery edge beam. Damping cables were then used to act as restrainers against wind action. These cables' action tie the whole system together. The totality of the cable configuration along the catenary surface gave the unique nature of the structure. Precast concrete elements were used to cover the cable network spaces.

these elements in form of tiles were held together by the means of wire strand attached to cable and held onto the precast element. Insulating material in form of felt was used finally. The drainage system of the structure was achieved through the configuration adopted.

9.8.6 Orientation

The building orientation after a careful survey of the existing local forces, gave birth to a concept which best utilize the shadding angle factor for the design comfort performance. Shadding devises were rprovided in places where they are deemed right.

9.8.7 Lighting

The planning of the structures was such that natural lighting was achieved in most of the functions. This provision came in form of orientating the building mass and the size of the openings provided. So therefore, the restaurant area, the lounge, discotheque were naturally lit. The approach was adopted on a multiuse scale to tackle the same problem.

9.8.8 Acoustic

For a high acoustical performance of the structure, a measure was adopted to screen the structure from the following noise sources:

(a) Air-borne noise.

(b) Structure borne noise.

For the air-borne noise generated by the traffic and the pedestrian movement, a special construction method was adopted which eliminates the impact of these nuisanc within the interior. One of the methods adopted was the use of double cavity wall and the use of plants as buffer. Special acoustical materials were provided at the lobby areas in form of floor and ceiling finishings. The auditorium seats had special acoustical absorbing materials making intelligibility possible when the auditorium is not in full capacity. The wall and the ceiling were specially treated as a reinforcement to interior audibility.

Special devises were installed at those places where facilities such as fans, air conditioners etc. were installed in order to reduce the structure borne noise generated. Resilient floor system was provided at the stage area to reduce the impact noise generated by performing actors/actresses.

9.8.9 Finishes

For a good visual apprehension and adaptability, the interior was finished with various types of materials, which induces a psychological acceptance to the users. For example, the entrance lobby adopted the mosaic floor finishes, art works for the wall finishes and concrete texture for the ceiling finishes; the offices adopted rug carpet and linolienm slate as floor finishes, plaster bonding acoustical material was used for the ceiling system; all other units adopted as earlier stated various patterns of interior decoration.

9.8.1. Landscaping

Landscaping elements of various types were located around the building. The integration of these landscaping elements with the structure enhances the site harmony.

Pocket system of landscaping was adopted, where plants are planted in patterns to create barrier intrusion into the land form. Terraces were carefully integrated into the la landscape form to define the pattern of movement around the site. Decidious trees were also planted to reduce site erosion and also provide good foliage covering for relaxation.

9.8.11 Parking

In order to create nigh circulation order on the site, a system of separating the vehicular traffic and the pedestri was devised. This takes the form of locating parking closer to function in use. The public parking was provided directly opposite the building facade for nearness, while the admin and the production units parking were located close to these facilities respectively.

9.8.12 Drainage

For an effective drainage of both surface and roofs, a channelisation scheme was devised along the building pheriphery so that water collected from the roofs and the surface are channeled through this system into the proposed university channel line.

9.8.13 Sewage disposal

Septic tanks were located closer to the toilets in order to avoid blockage of pipes that might be caused due to long distances and bending of pipes along this line.

9.8.14 Electricity supply

As proposed in the masterplan scheme, power supply shall be through the national grid network system along the site boundary. The local demand of the complex was met by this scheme outline.

9.8.15 Water supply

The water supply to the complex shall also respect the channelisation scheme proposed in order to meet the local demand requirement.

9.9 Conclusion

Right from the conception stage of the thesis subject proposal, various questions were generated along the design pursuance. These questions, inquisitive as they are, have tried to direct the researcher to find ways these generative problems could be solved, the recreational use pattern of Ahmadu Bello University community and its environs were critically analysed as regards social facilities provisions.

The cable technology which was conceived to generate fantastic form gave restriction along this development. This restriction came due to observance of some technical regulations. But nevertheless, the researcher has shown the understanding of cable technical aspects which would give room for the next generation of architectural creation.

The project conceptual planning scheme has given the avenues to exploit those elemental building components for a proper site harmony.

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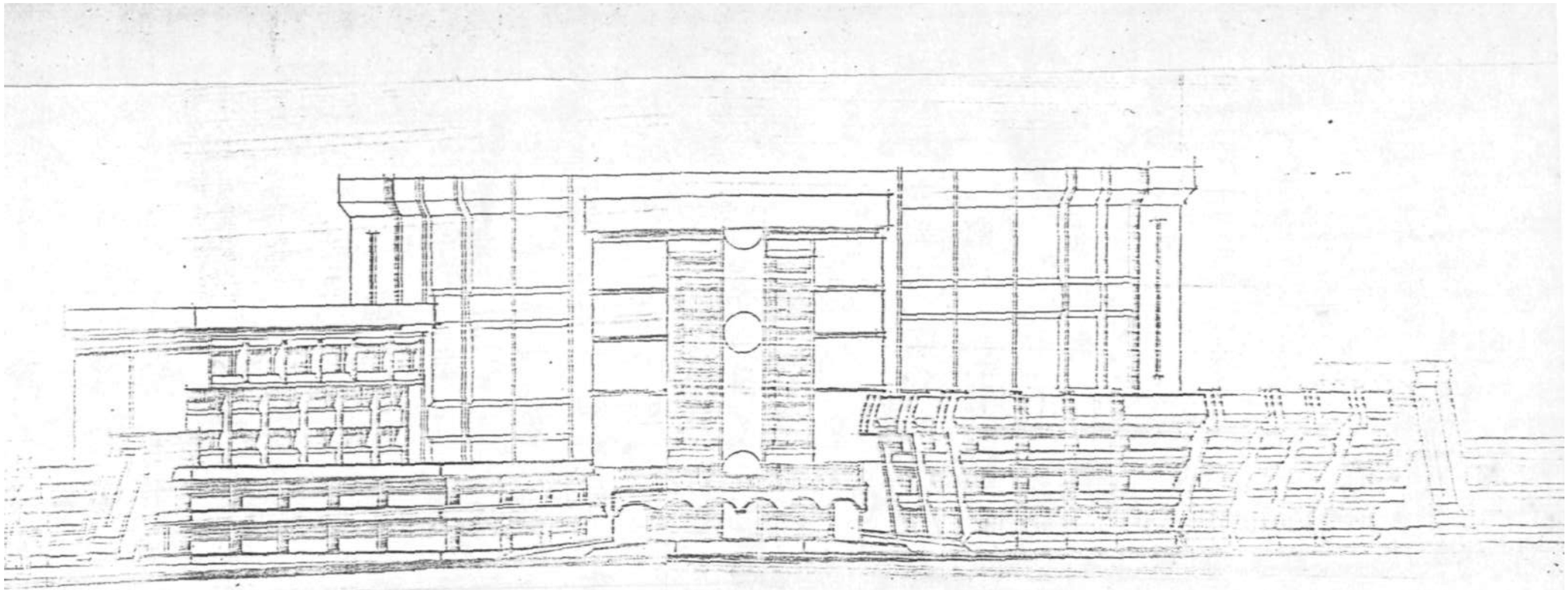
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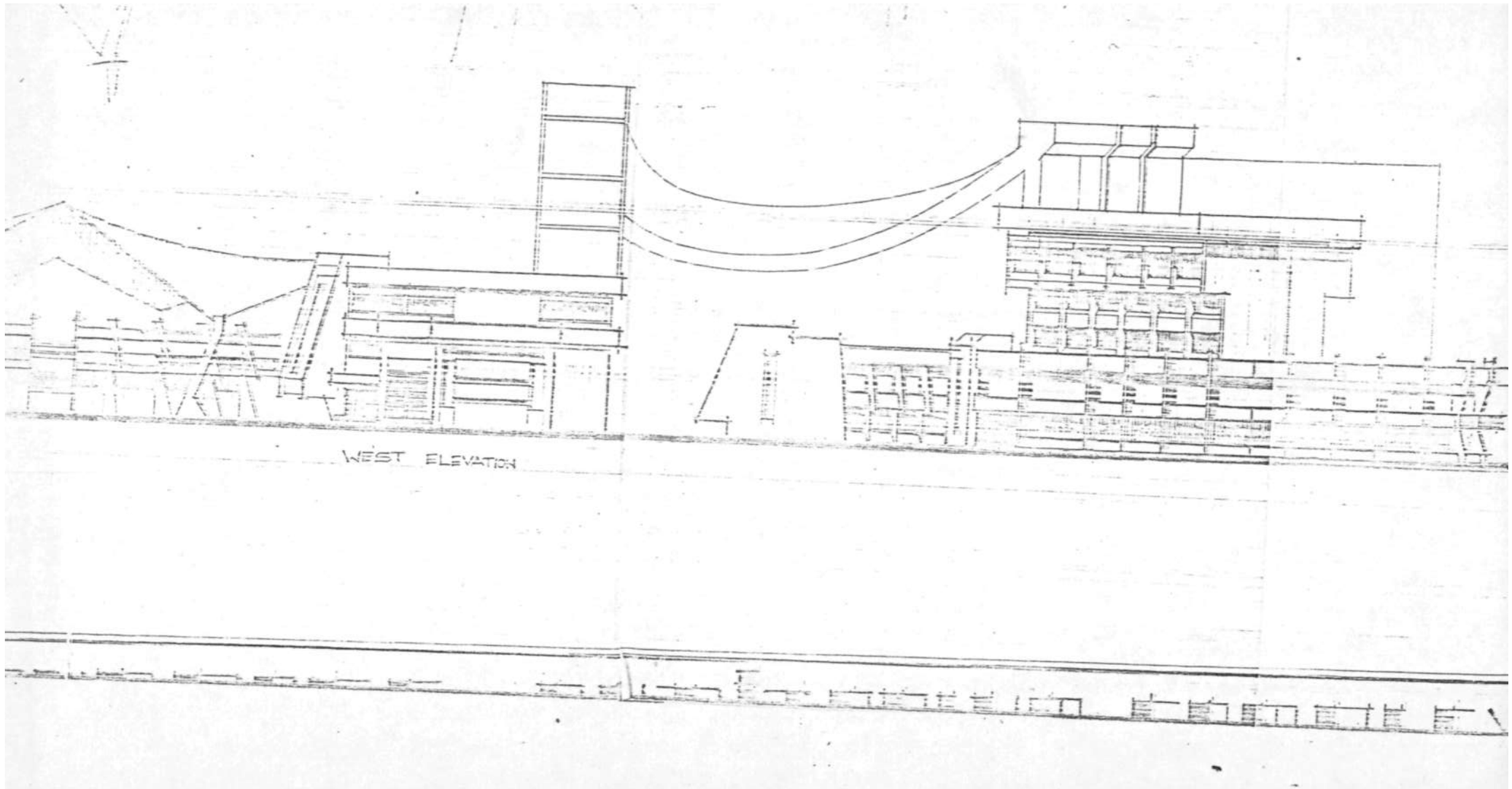
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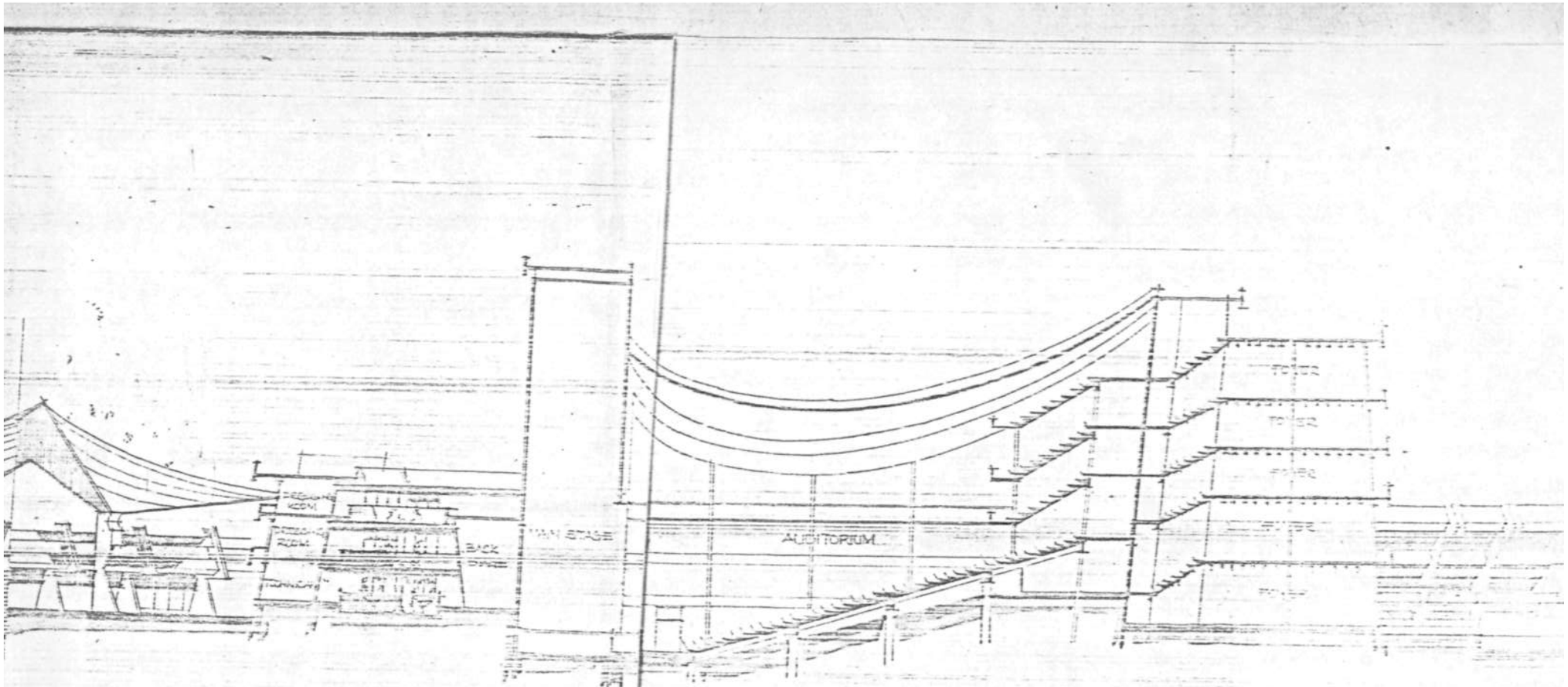
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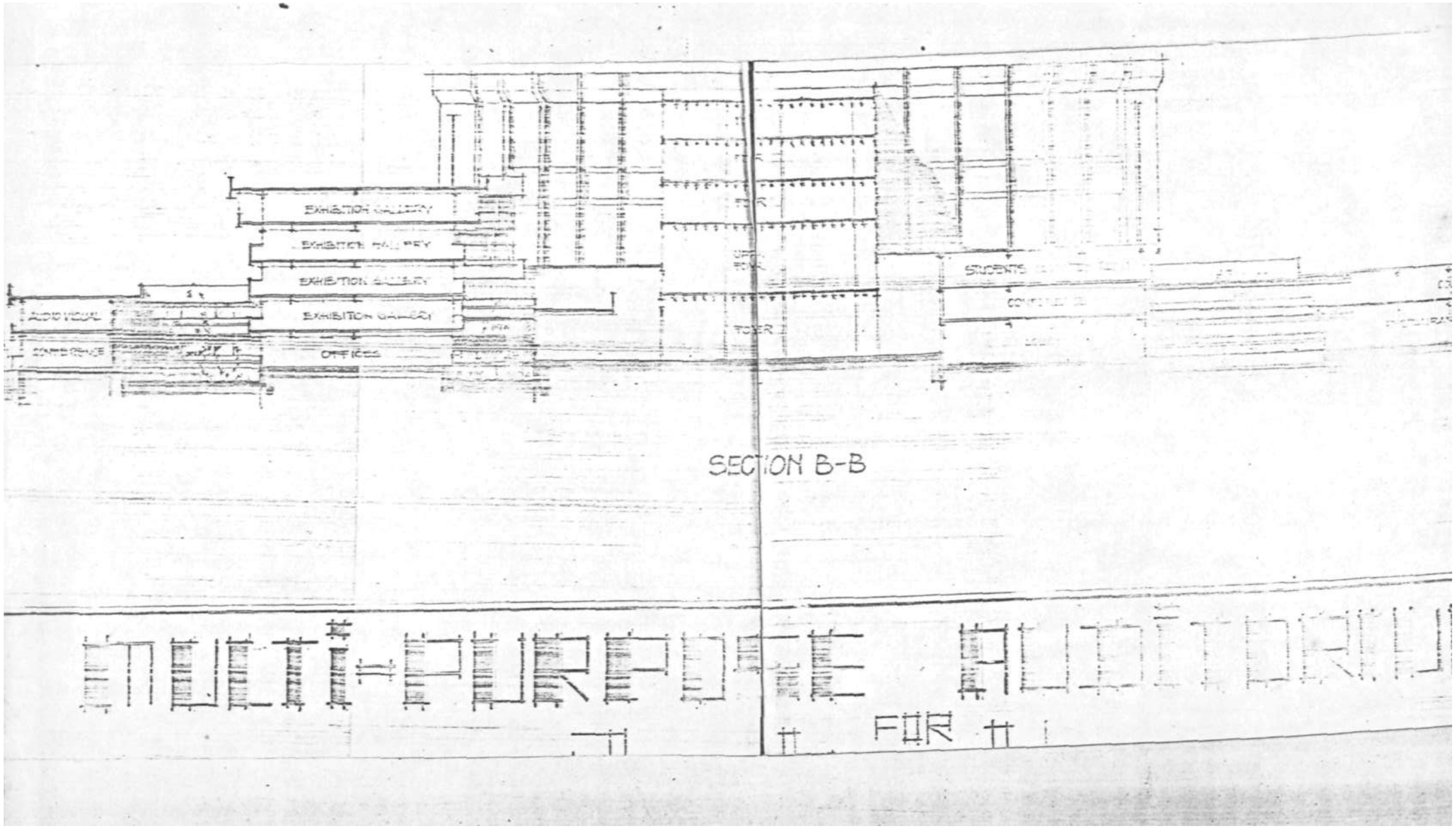
SOUTH ELEVATION



WEST ELEVATION



SECTION A-A


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EXHIBITION GALLERY
EXHIBITION GALLERY
EXHIBITION GALLERY
AUDITORIUM
OFFICES
TOWER
STUDENTS

SECTION B-B