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ENSURING THE STABILITY OF BUILDINGS IN NIGERIAN DEPRESSED ECONOMY:- THE ROLE OF STRUCTURAL ENGINEERS

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Abstract- Stability of buildings presently in Nigerian depressed Economy is a concern even beyond the professional circle. The reason for this is the fact that many lives and properties have been lost with such buildings that were found to be unstable in the past and even now. It is also believe that the present economy of the country is a contributing factor against the provision of high quality standard of buildings construction in the country. This paper examines the role of structural engineers in ensuring stability of buildings in Nigerian depressed economy

Key Words- Stability, Buildings, Structural Engineers, Responsibilities

I. INTRODUCTION: STABILITY OF BUILDINGS

The word stability is synonymous with steadiness poise and balance. It is time –based characteristic meaning resistance to change in concept. In the concept of structure a stable system is one that, when displaced by a small amount, will return to its equilibrium position. Conversely, all unstable system is one which, when displaced by a small amount, will continue to move away from the equilibrium position to the point it fails. The European council construction products directive 89/106/EEC [2.1]define a building to be stable when, "The loadings that are liable to act on it during its construction and use will not lead to:-

a. Collapse of the whole or part of the work
b. Major deformations to an inadmissible degree
c. Damage to other parts of the works or to fittings or installed equipment as a result of major deformation of the load bearing construction
d. Damage by an event to an extent disproportionate to the original cause. It should be clear from above statements that stability concerns function,

II. METHODOLOGY APPROACH

The adopted methodology for this paper are as follows:-

(i) A detailed study of reported causes of buildings and their collapsed in to different
(ii) Site visits to different places, where buildings are located without proper designs and construction supervisions are not followed up according to the press ional standards.
(iii) News paper and radio reports on collapsed buildings in the country

Figure 1Source: Punch News Paper Saturday 14th May, 2016 Two die, Six injured as government building collapse in Ogun

Figure 2 Source: Punch News Paper Saturday 14th May, 2016

III. THE STRUCTURAL ENGINEERS AND RESPONSIBILITIES

It should always be the case that the structural Engineers are the one responsible for the over all design of any building structural, with a duty to over see that the design and details of all elements and assemblies comply with the stability requirements. This responsibility applies equally where some or all of the structural design and details are developments by others, to new buildings as well as alterations and to both permanent and temporary structures.

The professional responsibilities under the structural engineers can be clearly illustrated under the following stated headings:-

Site Inspection

- It is a good engineering practice to all building sites before the design commences

Study of Architectural and topographic drawings

- The architectural and topographic drawings are carefully studied to conceive the design concept.

Preliminary design

- This is a quick and simple way of determining the member sizes of the elements and the workability of the structural concept

Sub-soil investigation

- It is always necessary to ascertain the carrying capacity of the soli before it is loaded- thus the sub soil investigation.

Analysis

- The structural analysis is done at this stage to confirm the adequacy of the assumed member sizes.

Members Design

The elements of the structure are then designed. If the members fail, their sizes would be reviewed and the preliminary design done again.

Final Design

This is done after the satisfactory completion of members design.

General Principles

This section outlines the general principles that apply to both preliminary and final design of reinforced concrete building structures, and state the design parameters that govern all design stages.

a. General

- It is always good for one engineer to be in charge of the total structural concept.
- The G.A. should be such as be able to transmit all the loads to the foundation.
- The structure should be robust and stable.
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b. Stability

- The structure must be stable in both directions against lateral forces. A system of strong points within the structure will ensure that the columns are not subjected to serious sway. A structure become unsafe when the occupants begins to be afraid of their safety inside of it's built

c. Robustness

- A structure is said to be robust when all the elements are effectively tied together in the longitudinal, transverse and vertical directs. It is such that a collapse of one element will not significantly affect the rest adversely.

d. Movement joints

Joints are to be provided in other to minimize the effect of movement caused by temperature variations, shrinkage e.t.c

e. Fire and Durability

- Provision for fire should follow laid down regulations. Joints should be well located to control cracks that are likely to be formed as a result of a fire incident.

f. Design Code

- In any design, the design code used should always be indication. A mixture of codes should be avoided.

Design principles-Reinforced Concrete

- Why Reinforced Concrete?
- Concrete is cheaper than steel
- Good combination of concrete & steel
- Durability from concrete covering
- Continuity from monolithic joint
- Reinforced Concrete (RC) Structure
- Concrete: high compressive strength but low tensile strength
- Steel bars: embedded in concrete (reinforcing) provide tensile strength

IV. DEIGN PRINCIPLE –STEEL & CONCRETE

Steel and Concrete in Combination

1. Bond between steel and concrete prevents slip of the steel bars.
2. Concrete covering prevent water intrusion and bar corrosion.
3. Similar rate of thermal expansion,

Concrete: 0.000010-0.000013
Steel: 0.000012

Design Principle-Dead loads

Loadings

-Dead Loads – Stationary Loads of Constant Magnitude

Dead Loads

- Caused by the weight of structure
- Include both the load bearing and non-load bearing elements in a structure
- Generally can be estimated with reasonable certainty

Design Principles- live loads

- live loads – moving loads or loads or loads that vary in magnitude
- Live loads
- floor loads
- Snow and ice: 50 – 200 kg /sq.m.
- Traffic load & pedestrian load for Bridges
- Impact loads = Gymnasiums, machines, engines
- Lateral loads: Wind & Earthquake

Design Principles- Loads for calculations loading

The loads to be used in calculations are:

(a) Characteristics dead load, Gk
(b) Characteristics imposed load, Qk
(c) Characteristics wind load, Wk
(d) Nominal earth load, En (BS 80047)

Design Principles- Horizontal forces

(e) At the ultimate limit state the horizontal forces to be resisted at any level should be the greater of:

(i) 1.5% of the characteristics dead load above that level +,

Or

(ii) 90% of the wind load derived from CP 3, Chapter V, and part 2[6], multiplied by the appropriate partial safety factor.

The horizontal forces should be distributed between the strong-points according to their stiffnesses.

Design Principles- limit States

- Limit states – The limit state principle with the partial factor format is adopted
  - Ultimate limit state – characteristic load (GK) X partial factor
  - Serviceability limit states – Not necessary if basic rules of l /d etc are observed.
- **Material and design stresses**

EC2 species concrete strength class by both the cylinder strength and cube strength (for example C25 / 30 is a Concrete with cylinder strength of 25 and cube strength of 30N / mm2 at 28 days).

- Economy – The design should be economical
- Environment – The impact of the structure on the environment should be considered.

Preliminary Design

- **General**
  - This is the stage where various design considerations are made for safety and for cost comparisons.
  - The aim should be to establish a structural scheme that is suitable for its purpose, sensibly economical, and not unduly sensitive to the various changes that are likely to be imposed as the overall design develops.
- Loads
- Material properties
- Structural system
- Stiffness
- Sizing

Loads

- Loads should be derived from the code being used.
- Reduction factors are not to be allowed in the preliminary design except for the foundation.
- Loading should be generous and not less than the following in the initial stages:
  - floor finish (screed) 1.8KN / m2
  - ceiling and service load 0.5kN /m2
  - Allowance for:
  - Demountable lightweight partitions 1.0kN /m
  - Block-work partitions 2.5kN /m
  - Weight of reinforced concrete should be taken as 24kN /m.

Material properties

- Concrete
- Concrete is a mix of: air, cement, coarse aggregates, fine aggregates and water
  - Water cement ratio

- Compressive strength
- Weights
  - Plain concrete – 23.3kn / m^2
  - Reinforced concrete – 24kn / m^

• **Steel**

- Round bars
- Deformed bars
- A steel characteristics strength fy of 410N/mm should be used for high-tensile reinforcement and 250N/mm for mild steel.

V. STRUCTURAL SYSTEM

The following measures should be adopted:

(a) Provide stability against lateral forces and ensure braced construction by arranging suitable shear walls deployed symmetrically wherever possible

(b) Adopt a simple arrangement of slabs, beams and columns so that loads are carried to the foundation by the shortest and most direct routes

(c) Allow for movement joints

(d) Choose an arrangement that will limit the span of slabs to 5m to 6m and beam spans to 8m to 10m on a regular grid; for flat slabs restrict column spacing to 8m

(e) Adopt a minimum column size of 300m x 300mm or equivalent area

(f) Provide a robust structure.

- The arrangement should take account of possible large openings for service and problems with foundations, e.g. columns immediately adjacent to site boundaries may require balanced or other special foundations.

Stiffness

- To provide adequate stiffness, the effective depths of bears, slabs and the waist of stairs should not be less than those guided by the code.
- Beams should be of sufficient depth to avoid the necessity for excessive compression

Reinforcement and to ensure that economical amounts of tension and shear reinforcement are provided. This will also facilitate the placing of concrete.

Member sizes

- When the member sizes have been determined, checks should be carried out to confirm the practicality of reinforcement arrangements in beams, slabs and at beam-column junctions.
- Beams and ribs widths should be determined by limiting the shear stress in beams to 2.0N/mm2 and in ribs to 0.6N/mm2 for concrete of characteristic strength f ck ≥ 25N/mm2:

- width of beam (in mm) = 1000V/2d
- width of rib (in mm) = 1000V/0.6d where V is the maximum shear force (in kN) on the beam or rib, considered as simply supported and d is the effective depth in mm.

- Preliminary engineering drawings of the different options considered are then prepared and distributed to all concerned for costing and comments.

Final Design

After receiving all comments

- When all the comments have been received all the information received would be arranged ready for use in the final design. This may be carried out in the following sequence:

(1) Checking of all information

(2) Preparation of a list of design data

(3) Amendment of drawings as a basis for final calculations.

Carry out final design calculations of the elements prepare engineering report

Information to check

- Information on the following are checked to ensure the validity of the design assumptions.

- Stability
- Movement joints
- Loading
- Fire resistance, durability and sound insulation

Foundation

- Foundations

- Examine the information from the ground investigation and decide on the type of foundation to be used in the final design. Consider especially any existing or future structure adjacent to the perimeter of the structure that may influence not only the location of the foundations but also any possible effect on the superstructure and on adjacent buildings.

Final design Calculations

- The final design calculations for the structure can be commenced when all the above checks, design information, data lists and preparation of the preliminary drawings have been carried out. Preparations of the preliminary drawings have been carried out. These should be carried out in a logical sequence.

- The remaining items of work for final design are as listed below

- Slabs
- Structural frames
- Beams
- Columns
- Walls
- Staircases
- Retaining walls, basements
- Foundations
- Robustness, and
- Detailing.

Robustness

- The reinforcement already designed should be checked to ensure that it is sufficient to act as:

(a) peripheral ties
(b) internal ties
(c) External column or wall ties
(d) Vertical ties

- Reinforcement considered as part of the above ties should have full tension laps throughout so as to be effectively continuous.

Detailing

- This is a very vital aspect of the entire works.
- A badly detailed structure will end up not serving its purposes and may collapse.
- particular attention should be paid to bond and lap lengths.

VI. RECOMMENDATION

(i) In order to avoid incessant building collapse due to lack of stability, government and the public should check in compatible land uses where offices are located in residential offices, industry next door to schools, church sharing the same premises with a residential buildings

(ii) The monitoring department in all government ministries should be alert in their responsibility in terms of adequate and proper supervision and checks to any building construction site.

(iii) Professional societies, e.g. Institution of structural engineers should wake up to their responsibility and to make sure registered structural engineers are involve in designing complete buildings and also in the execution or implementation order. By doing this, we can

be sure that buildings designed with their construction procedures followed, will end-up resulting into building that are rated with high standard of stability

VII. CONCLUSION

Stability of buildings in a county like Nigeria as becomes a major issue of concern to every body, especially in major cities and towns in the country. Buildings are like human beings, and when they are not tended well show signs of decay. This could manifest in various way that include, but not limited to calling in or even surrendering the various loads.

Buildings like other structures are usually designed to support certain loads without deforming excessively. The loads are the weights of people and objects, the weights of rain, pressure of wind-called live loads and the dead weight of the buildings itself. Any type of building can collapse without proper due respect to the stability. The recent report on the collapse of Buildings in many parts of the country is a proof that such buildings lack structural stability, which is the responsibility of structural Engineers.

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