COST OPTIMIZATION ANALYSIS OF RC FRAME BUILDINGS WITH SYSMIC LOADS

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ABSTRACT:

The concept of soft storied buildings has taken its place in the Indian urban environment due to the fact that it provides the parking facility in the lower stories of the buildings. Surveys of buildings failed in the past earthquakes show that this types of buildings are found to be one of the most vulnerable to seismic forces. The collapse mechanism of such type of building is predominantly due to the formation of soft-story behavior in the ground story of this type of building. The sudden reduction in lateral stiffness and mass in the ground story results in higher stresses in the columns of ground story under seismic loading. In conventional design practice, the contribution of stiffness of infill walls present in upper story of open ground story framed buildings are ignored in the structural modeling. In this study, static and dynamic analysis of open ground story RC frame with different infill materials using ETABS will be evaluated and the results compared. The three dimensional RC frame will be considered with assumed sizes of structural members like size of columns, size of beams and thickness of slab. Initially, the material properties are assumed as per code specified. The response simulations will be performed for different categories of bare frame and in filled frame. In this project two types of blocks are used, that is clay brick and fly ash brick. Masonry infill walls have been used in reinforced concrete frame structures as interior and exterior partition walls. Infill substantially alters the behavior of the building subjected to lateral loads such as wind and earth quake forces. However when subjected to a strong lateral loads, infill panels tends to interact with bonding frame and may induce a load resistance mechanism that is not accounted for the design. From the studies fly ash in-filled structure having low value of displacement, drift and period of vibration, due to this it is hypothetically concluded as fly ash is better infill material than brick infill.

Keywords: *RC frame, E-tabs*

1.0 INTRODUCTION

High strength steel and concrete has gained increasing attention recently in reinforced concrete (RC) buildings due to the need to limit the size of structural members in high-rise buildings.

- Some benefit of using high strength steel and concrete: a. Increasing available floor area b. Reducing reinforcement congestion in beam-column joints and plastic hinge regions of columns and beams c. Column section along the height of the building can be uniformly designed by using higher material strength in the lower stories
- Limitation of current ACI 318M-11 of specified yield strength of transverse reinforcement and concrete compressive strength for shear design of 60 ksi (420 MPa) and 10 ksi (70 MPa) respectively

During the past few years, high-strength concrete (HSC) has been generating increased interest amongst civil and structural engineers. The expanding commercial use of this relatively new construction material can be explained partially by the life cycle cost-performance ratio it offers, as well as its outstanding engineering properties, such as higher compressive and tensile strengths, higher stiffness and better durability, when compared to the conventional normal strength concrete (NSC). From a historical point of view, in the middle of the 20th century concrete with characteristic strength (fc) of 25MPa was considered high-strength. In the 1980s, 50MPa concrete was considered high-strength. About two decades ago, HSC was mostly specified for projects as an alternate design. But today, HSC is being specified in the preliminary design stage as a sensible solution for concrete construction. Nowadays, technology for producing HSC has sufficiently advanced such that concretes with compressive strengths of up to about 120MPa are commercially available, and strengths much higher than that can be produced in the laboratories. The significant economic advantages of HSC are very well-documented, and evident from the number of recent construction projects where HSC has been used successfully. The use of HSC for construction, especially for multi-story buildings, has become very common in industrialized and developing countries. In Australia, where the majority of buildings are concrete structures, almost all concrete high-rise and medium-rise building projects utilize HSC. Australia has taken the advantage of the benefits of high-strength concrete through its widespread use on buildings such as 120 Collins Street, Melbourne Central, the Rialto project in Melbourne, the 43- story high Cassel den Place project in Melbourne. In Seattle USA, the strength of concrete used on the Pacific First Centre was about 125MPa The Freedom Tower in New York City, which will be one of the world's tallest superstructures, is projected to be completed in 2010. The structure consists of a robust high-strength concrete core paired with a highly redundant perimeter steel moment resisting frame. Most experience on HSC in Europe has been gathered in Norway, with that country's development in offshore platforms, bridges, and highway pavements In Germany, HSC was first utilized in a high-rise building in Frankfurt, completed in 1992. HSC with a mean strength of 100 MP a was used in the PETRONAS Towers in Kuala Lumpur in 1998. The Eureka Tower, which is one of the tallest buildings in Australia was completed in 2006 has utilized HSC up to 100 MPa. In general, concrete is not considered as a sustainable construction material in terms of large consumption of raw materials, contribution to greenhouse gas emissions from cement and low durability. The ruling argument is that the production of 1kg of cement which, is the main ingredient of concrete, generates 0.8 - 0.9kg of CO2 emission It is commonly argued that with a high growth rate, the demand for concrete consumption will substantially increase in the near future imposing a heavy burden on the ecological system. The CO2 emission related to concrete production, inclusive of cement production is between 0.1 and 0.2tonne per 1tonne of produced concrete .

The environmental impact of concrete as a construction product is questionable with studies demonstrating concrete products requiring much less energy with a lower net environmental impact when compared to other construction materials such as steel Regardless of the impact to the environment, it is a true fact that currently urbanization worldwide relies heavily on the concrete industry. Worldwide, some 6 billion tons of concrete is produced per year, making concrete one of the world's most popular construction materials. On the economic front, this represents about 13 to 14 trillion USD world trade dealing In view of the importance of climate change, sustainability has become the main concern for the concrete industry. In order to assess the environmental impact of concrete, a multi-dimensional, lifecycle approach is adopted The findings show that, when considering the life-cycle stages of the product into consideration in order to carry a comprehensive and impartial assessment, concrete can be considered as a material that burdens the environment least It is further reported that using high performance concrete has multiple environmental benefits. For instance, it is possible to build a durable structure with minimum maintenance that lead to a reduction in the consumption of raw materials and greenhouse gas emissions, and reclaiming industrial waste products and using them as effective construction materials In spite of this, steps have been taken in place to reduce the CO2 emissions into the atmosphere. In order to limit the usage of Portland cement, the concrete industry has been increasingly inclined towards substituting Portland cement with fly ash, slag and micro silica fume all which are industrial byproducts. It is believed that this substitution can be increased without impairing the performance of the concrete grades this paper presents literature review of current studies undertaken on HSC. The review is divided into two parts. In the first part, the main constituents of HSC are presented. The main ingredients which influence the performance of HSC are discussed the addition of mineral admixtures which are mostly industrial by-products is common in the production of HSC. The effects of these admixtures on the concrete properties are also discussed. On the second part, the engineering properties of HSC concrete are presented for the purposes of this paper, HSC is defined as concrete with compressive strength, fc, in the range of 50 - 100 MPa. NSC is concrete with f'c< 50 MPa.

Residential apartments and high rise buildings are increasing exponentially in our country in urban cities due to change of lifestyle. High rise buildings provide a decent shelter with minimum possible area of land for the maximum utility at a reasonable cost.

FIGURE 1.1 Collapse of RC Building Due To Insufficient Lateral Stiffness

OBJECTIVES:

The objective of this thesis is to investigate the structural behavior of medium to high rise frame building with reinforced HSC columns subjected to seismic lateral load in addition to gravity loads. In light of this, the variation of the different structural responses due to change in columns concrete strength for regular moment resisting building frames will be studied. This will provide data which determines the need for using HSC columns over NSC for medium to high rise buildings and the HSC will be given attention by structural designers. The obtained data which is related to structural responses will act as a supportive document for possible decision to be made on the need for awareness creation in using HSC column and increase confidence that it can be used economically for high rise building frame

SCOPE OF STUDY:

The scope of the study are to carry out an ETABS software analysis on IBS wall block work components and investigate the mechanism of failure due to applied external vertical loads. Stresses induced from early mentioned loads that will stream in components, resulting in crack and spelling of the whole system. The scope is to include the behaviour and strength, deflection and pattern of failure of the models

2.0 LITERATURE REVIEW

[1] Chandler &Mendis (2000) compared the force and displacement based method procedure on moment resisting frame. A study was presented on reinforced concrete moment-resisting frames designed and detailed according to European and Australian earthquake code provisions, having low, medium and high ductility capacity. They found that the OMRF and IMRF developed plastic hinges in the columns under the El Centro earthquake. The SMRF generally developed plastic hinges in beams rather than column which are consistent with ACI 318-95 strong column-weak beam detailing philosophy used in the design of SMRF.

[2] Yong Lu et al (2001) studied and investigated the selection of adequate ductility levels and the corresponding seismic force reduction factor for a specific class of structures, whereas the detailing requirements to ensure the desired ductility continue to be refined. In their investigation, three simple frames were designed for different ductility levels according to EC8 and confirmed that the satisfactory performance was observed in the frame designed for medium ductility due to reduced damage level. Under the "ductility for seismic force reduction", the experimental observations suggest that frames designed for high ductility (thus large reduction of design seismic force) are likely to attract more extensive damage than those designed for lower ductility, due to large yield excursion.

[3] SashiKunnath&ErolKalkan (2004) studied the seismic deformation demands using nonlinear procedures in multi-story steel and concrete moment frames. Pushover and non-linear time-history analysis were carried out on eight and twelve story steel and concrete moment frames using SAP2000 software. Three different lateral load configurations suggested in FEMA-356 were used for the pushover analysis. They concluded that the difference in base shear capacity between the different patterns decreases with story height. The difference was more evident for the steel building, since the increase in story height produced a larger change in fundamental period than the RC building

[4] Bing Li &Tso-Chien Pan (2004) described the seismic performances of reinforced concrete frames under low intensity earthquake effects. A study was conducted on 6 storey moment resisting frame. It was found that for the strong direction frame only moderate damage may be caused, while for the weak direction frame severe damage may occur. Nonlinear dynamic analysis has shown that a low intensity earthquake might cause the frames to generate a maximum inter-storey drift ratio of about 2%. Diagonal tension cracks in the joint core region extended and the number of those cracks increased rapidlyinvestigated seismic performance of moment resisting frames for its lateral load resistance, distribution of inter-story drift and the sequence of yielding of the members. In the study, a typical 5-storey frame was designed as (a) ductile, (b) nominally ductile, (c) GLD, and (d) retrofitted GLD. This study presented an analytical approach for seismic assessment of RC frames using nonlinear time history analysis and push-over analysis. It was concluded that both the ductile and the nominally ductile frames behaved very well under the considered earthquake, while the seismic performance of the GLD structure was not satisfactory.

[5] Sudarshan Brahma &KaustubhDasgupta (2011) studied the influence of structural wall area ratio on seismic design of concrete wall frame buildings. An analytical study was conducted on a 5 storey reinforced concrete building with and without shear wall in Seismic Zone V using SAP2000 software. Shear wall area ratio (defined as the ratio of wall area in plan to the floor plan area) is gradually increased from 1% to 5%. It has been observed that increasing the shear wall area ratio for placing the shear walls reduces the demand in the structural wall and in various columns in the building. The fundamental time period of the structure shows a decreasing trend with increasing in shear wall area ratio due to the significant increase in the lateral stiffness of the building.

3.0 DESIGN OPTIMIZATION OF RC FRAMES

Formulation of the optimal design problem requires identification of design variables for the structural system,objective function that needs to be minimized, and design constrains that must be imposed on the system. Oncethe design problem has been formulated, it is transcribed into the following standard constrained optimizationmodel:

3.2 DESIGN VARIABLES:

Using one column size for each story or for a number of stories and varying the amount of reinforcement willsimplify construction form. For a line of continuous beams, keeping the beam size constant, even when loadsand spans differ, and varying the amount of reinforcement from span to span will also simplify the constructionof forms. In both cases, less labor will be used, fewer supervisors and inspectors will be needed, and costs willbe lower. These ideas are employed in this study as the basis of a general strategy for frame economy.For the present formulation, cross-sectional dimensions and reinforcement areas for columns and beams aretaken as design variables. Specifically, for columns there exist three design variables: the width, *bc*, the effectivedepth, *dc* and the longitudinal reinforcing steel area, *ASt*Also, for beams there exist three design variables:

The width and the effective depth of the web, b_w and d_B, respectively, and the tensile reinforcing steel area, *As*. For each story, the design variables pertaining to the concrete sections are linked, meaning that the column width are assigned the same design variable as well as each of the column effective depths, beam widths, and beam effective depths. This gives practical designs facilitating the use of repetitive formwork. For each story, there are onlytwo design variables pertaining to the reinforcing steel. These are the longitudinal reinforcing steel area in themost critical column and the tensile reinforcing steel area at the most critical location of bending moment in beams. Each member contains only the minimum amount of area of steel that required satisfying the imposed constraints.

The objective function which must be minimized is the function calculates the total cost of the frame. It is expressed in terms of concrete volume, steel weight, formwork surface area as well as their unit costs. The total

where:

C columns = cost of columns for the whole frame.

C beams = cost of beams for the whole frame.

cost of a reinforced concrete plane frame can be expressed as:

Cost = *C* columns +*C* beams

where:

C_C = cost of concrete per unit volume.

S_C = cost of steel, ties, and stirrups per unit weight.

F_C = cost of formwork per unit surface area.

S_N = number of stories.

C n = number of columns per story.

b n = number of beam per story.

S γ = unit weight of steel.

CC_V = volume of concrete in a column, calculated by using Equation (4).

CS_V = volume of longitudinal reinforcing steel in a column, calculated by using Equation (5).

t_V = volume of lateral ties in a column, calculated by using Equation (6).

Cf_A = surface area of formwork for a column.

bC_V = volume of concrete in a beam, calculated by using Equation (7).

bS_V = volume of tensile reinforcing steel in a beam, calculated using Equation (8).

v_V= volume of stirrups in a beam, calculated using Equation (9).

bf_A = surface area of formwork for a beam.

$V_{CC}= A_{GC}\ L\ u$

Agc = gross cross-sectional area of column.

Lu = unsupported length (clear height) of column.

Lc bars V = A

TABLE 3.1 X-SECTIONS BEAM COLUMN:

X SECTION	BEAM	COLUMN

b	0.25	0.22	0.45	0.4	0.35	0.3	0.3	0.22
h	0.5	0.45	0.45	0.4	0.35	0.5	0.3	0.45

4.0 RESULT

4.1 CONCRETE COLUMNS OF R C FRAME STRUCTURE ANALYSIS

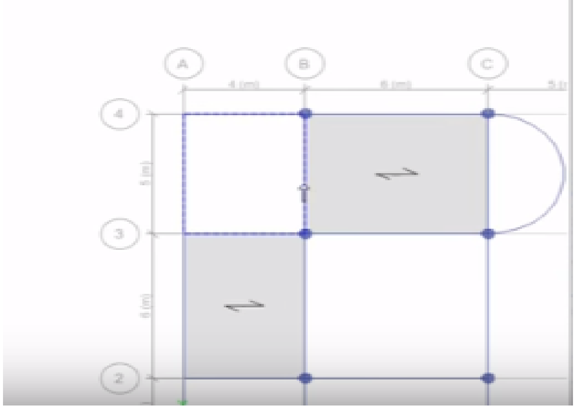


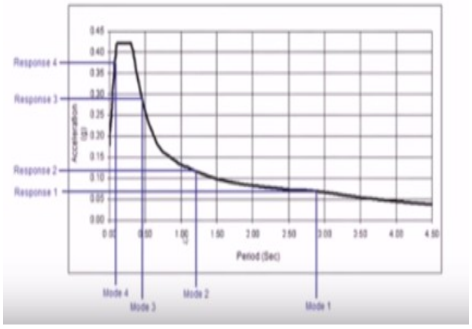
Fig 4.1 Plane view of the rc frame building

The Fig 4.2 Shows That Base Of The Rc Building

The Fig 4.3 Shows That Torisinal Mode Of Y-Direction In Rc Building

TABLE 4.1 X- COORDINATE SYSTEM GRIDE DATA

Gride Id	X-Coordinate	Veriable	Double loc
A	0	yes	End
B	8	yes	End
C	16	yes	End
D	24	yes	End



The Fig 4.5 Shows That Spectrum Plane Response Curve

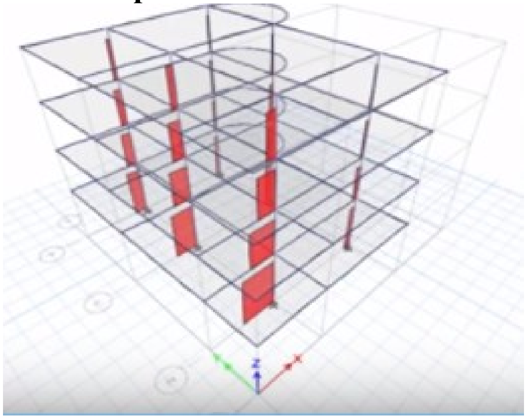
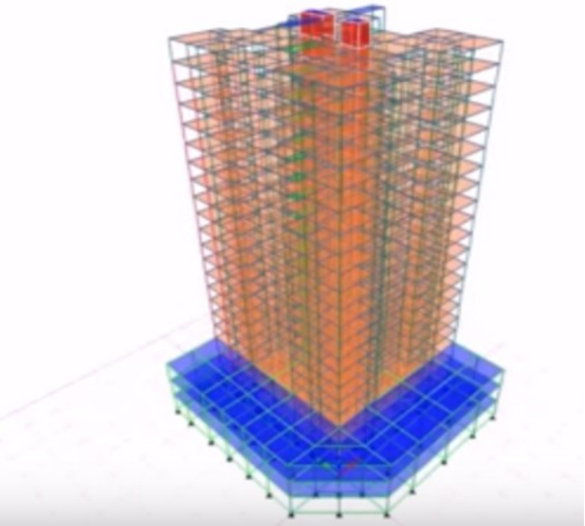
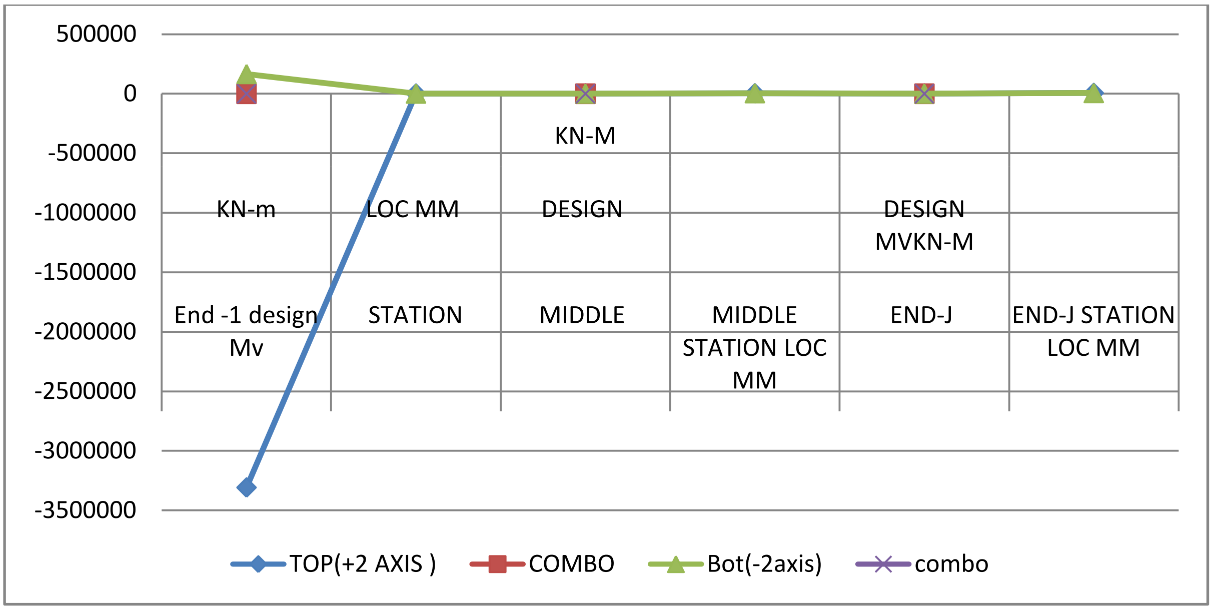


Figure 4.6 visuval shape of the rc frame structure



The fig 4.7 shows that spectrum Rc building shape



Graph 4.1 FLEXURAL DESIGN MOMENT

5.0 CONCLUSIONS

The study undertaken is intended for regular frame buildings representing medium to high rise structures. The assumptions made and the study approach limited the number of variables that could affect the structural behavior of HSC. Therefore, with different approach which could consider different variables, further research regarding structural responses of reinforced high strength concrete columns of medium to high rise buildings is essential The structural performance and economic advantages of HSC are attracting designers to use HSC for columns of buildings. Thus, even though the design of HSC members preceded theresearch to be undertaken, the importance of continued research on HSC at the structure level iscrucial in providing sufficient knowledge of the performance of HSC structures so that the safetyof design practices will be ensured.The result showed that the maximum interstate drifts are within the limit and slightly higher for frames with HSC columns, but the contribution of the concrete strength in resisting the lateral deformation was obtained to be substantial. Economic comparisons were also made and it was found that the most economical frame corresponds to the highest available columns.

OBSERVATIONS:

- Curvature ductility slightly enhanced with higher concrete strength of the columns.Flexural strength of the column section decreases with the increase in column concrete strength.
- The ultimate strength is substantially higher than the yield strength for NSC column section, but it becomes comparable to the yield strength of the section as column concrete strength increases.
- The columns concrete deformation at ultimate decreases with increasing columns concrete strength. Lesser stories stiffness due to smaller column sections dimensions are obtained for frames with higher column concrete strength.

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