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Comparison of High Grade Concrete in Earthquake Prone Areas

A.A.Gudadhe[1]

[1]Assistant Professor, Datta Meghe Institute of Engineering, Technology & Research,
Salod (H), Wardha - 442004, Maharashtra

ABSTRACT

On the edge of 21st century 75% of world populations are still living in structures, which are not earthquake resistant. There by causing the most losses of life, property & wastage of money as they are not using proper mix design & proper grade of concrete for construction. The main aim of the paper is not merely the analysis & design of structure but to understand the meaning of mix design & promoting the high grade concrete to reduce the cost of construction & to get the better strength, life & it may also reduce the losses of lives, property & money.

In this paper seismic analysis of multistoried building (G+3) is done for Zone-III. As mention in I.S. Code 1893-2002 (Part I) that structure will normally experience more ground motion, which is given in the code for design purpose. However, in view of the energy absorbing capacity available in inelastic range, ductile structure will be able to resist such shocks without much damage. Generally for two–three storied building analysis is not done. Axial load is calculated & it is increased by some percentage for considering the effect of moment. It is not wrong for short structures, for long span structures effect of moment is very large. Therefore this assumption gives in accurate results. So analysis is done for getting results. The paper comprises comparative study for cost reduction & saving in cement by using some mineral admixtures in M20 & M35 grade concrete.

Keywords: Earthquake, High Grade Concrete, Mix Design, Analysis & Design

1. INTRODUCTION

The design approach adopted as per I.S. Code is to ensure that structures posses at least a minimum strength to withstand minor earthquakes design base earthquake (DBE), which occur frequently, without damage; resist moderate earthquakes without significant structural damage though some non-structural damage may occur and aims that structures withstand a major earthquake maximum considered earthquake (MCE) without collapse. Actual forces that appear on structures during earthquakes are much greater than the design forces specified as per I.S. Code. However, ductility, arising from inelastic material behavior and ductiling, and over strength, arising from the additional reserve strength in structures over and above the design strength, are relied upon to account for this difference in actual and design lateral loads. Reinforced and prestressed concrete members shall be suitably designed to ensure that premature failure due to shear or bond does not occur, subject to the provisions of IS 456 and IS 1343. Provisions for appropriate ductile detailing of reinforced concrete members are given is IS 13920. Earthquake is a shaking of the ground caused by sudden breaking and shifting of the large sections of the Earth’s rocky outer shell. Earthquakes are among the most powerful events on the earth, and their results can be terrifying. A severe earthquake may release energy about 10,000 times as great as that of the first atomic bomb. Scientists estimate that more than 8,000 minor earthquakes occur daily without causing any damage. Of these only about 1,100 are strong enough to be felt. The world’s deepest earthquakes occur in subduction zones down to a depth of about 700 km below that depth the rock is too warm and soft to break suddenly and cause earthquakes.

Quake vibrations are so intense that they turn soil into a jelly. The violent ground motions pushes the building rapidly from one direction to another making it difficult for the superstructure to constantly balance its load resulting in the collapse of structures. Earthquake damage depends upon many parameters including magnitude, intensity, duration and frequency content of ground motion, geologic and soil condition, quality of construction, etc. The only thing in our hand is the planning, design & quality of concrete & construction. Even prediction of Earthquakes will not be fruitful.

Adam Neville defines mix design as the process of selecting suitable ingredients of concrete and determining the relative quantities with the object of producing as economically as possible concrete of certain minimum properties, namely consistence, strength and durability.

2. MIX DESIGN

Concrete mixes be designed for a particular set of given ingredients to produce the specified properties of concrete in the most economical way. This is especially needed for large scale jobs where quality is an important yardstick. Such concrete is known as “Design mix concrete” or “Controlled concrete”. Mix designing is a process by which one can arrive at the right combination of cement, aggregates, water and admixtures, if any, for producing concrete to satisfy given specifications.

The purpose of mix proportioning is to obtain a product that will perform to certain predetermined requirements. Some of the most essential requirements are: workability of fresh concrete, strength of hardened concrete at specified age and its durability for the specified external environment. Another important requirement is the economy, which involves decisions regarding the selection of ingredients that are not only suitable but are available at reasonable prices.

Thus the objective of mix design is to ensure that concrete:

- Complies with the compressive strength as laid down in the specifications.
- Conforms to the specified durability requirements to resist the environment in which the structure will be serviceable during its design life
- Has adequate workability
- Is capable of being mixed, transported, laid and compacted as efficiently as possible
- And last but not the least, be as economical as possible

Recommendations:

- The details of mix recommended are as follows:

Table 1: Details of mix

Grade of Concrete	Mix Proportion	Water Cement Ratio	Cement Content (kg/m³)	Sand Content (kg/m³)	Coarse Aggregate 20mm (kg/m³)	Coarse Aggregate 10mm (kg/m³)	Water Content (kg/m³)
M20	1:1.71:3.41	0.5	377.58	646.15	644.2	644.2	188.79
M35	1:2.1:3.92	0.575	328.33	689.94	644.105	644.105	188.79

- The qualities of aggregates should be checked at regular intervals.
- In order to maintain the workability, proportionate adjustment in the quantity of water should be done, if the material i.e. sand and aggregates received are in wet or dry conditions.

3. Analysis Problem

In this a ten bay four-storied RCC structure is analyzed for Zone III. The seismic coefficient method is used for the analysis. After the manual calculation of the forces & base shear acting on the structure, the software STAAD-PRO is used for analysis finally the design forces of the structure are calculated & the reinforcement given by the analysis is used for preparing estimate & schedule of bars. The two grade of concrete i.e. M20 & M35 and steel required for this purpose a mix design of M20 & M35 grade of concrete has been performed.

Building plan consist of ground floor of 10 nos. shops of size 3.43m x 4.57m. First floor also consist of 10 nos. of shops of size 3.43m x 4.57 m. Second & Third floor consist of 2 halls. Thus the entire building had been analyzed by dividing into number of individual frame. As per IS-875: 1987 live load for terrace had been taken as 1.5 kN/m and for roof as 6 kN/m.

The analysis has been carried out for Dead Load (D.L.), Live Load (L.L.), Earthquake Force (Eq.L.) in all possible direction, i.e. sway to left (X.Left), (X.Right), (Z-up) & (Z-down) by standard computer package Stadd-Pro. The six basic loads & the 13 combinations of the above loads has been made according to Cl.6.3 (6.3.1.2) of IS:1893(Part I)-2002 & IS:875-1987 are given below.

1. D.L.
2. L.L.
3. Eq.L. – X LEFT
4. Eq.L. – X RIGHT
5. Eq.L. – Z UP

4. Tabulation & Comparison

Table 2: For M20 & M35 Grade of Concrete

Sr. No.	Particulars	No.	M20 Grade of Concrete				M35 Grade of Concrete			
			L	B	D	Quantity / Unit	L	B	D	Quantity / Unit
1.	Column	20	0.3	0.6	14.6	52.56	0.3	0.45	14.6	39.42
2.	Beam in X-direction	126	0.23	0.4	3.43	39.76	0.23	0.38	3.43	37.77
3.	Beam in Y-direction	54	0.23	0.45	6.07	33.93	0.23	0.45	6.07	33.93
4.	Cantilever Beam in Y-direction	12	0.23	0.45	1.5	1.86	0.23	0.45	1.5	1.86
Total Concrete required						128.11				112.98
Total Steel required						12112.73				11257.30

5. Results

It has been observed that, in case of beam steel required is more at support, in case of DL+50%LL+EQL, while at centre steel required is more in case of DL+100%LL. From earthquake point of view, finalizing the size of column is very much essential. When size of column decided as 0.23 m x 0.45 m for M35 grade concrete, it is observed that increased in percentage of steel is very large, where as when size of column decided as 0.3 m x 0.38 m for M35 grade it is observed that given section is inadequate. It is also found that amount of steel required for M35 grade of concrete is less than that of M20 grade concrete. The size of column maintained in M35 grade as 0.3 m x 0.45 m throughout & in M20 grade as 0.3 m x 0.6 m throughout. Thus by providing higher grade of concrete structure can be made more economical.

6. Conclusion

The use of higher grade concrete such as M35 will be economical because of minimum reinforcement requirement at all levels as compared to M20 grade of concrete. By using higher grade of concrete such as M35 the concrete is saved up to 16 cu.m. and steel up to 856 kg. No advantage in reducing size of column below 0.3 m x 0.45 m in M35 grade of concrete was observed as per Staad Pro analysis. And finally the consumption of cement can be reduced if properly graded aggregates and high grade cement along with admixtures are used.

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AUTHOR

A. A. Gudadhe received the B.E. degree in Civil Engineering from Prof. Ram Meghe Institute of Technology & Research, Badnera in 2006 and M.Tech. degree in Structural Engineering from Yashwantrao Chavan College of Engineering, Nagpur in 2008. Currently, he is working in Datta Meghe Institute of Engineering, Technology & Research, Wardha as Assistant Professor in Department of Civil Engineering since 2010.