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"ANALYSIS AND DESIGN OF FLAT SLABS OF UNEQUAL SPANS WITH RESPECT TO DIFFERENT CODES"

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***Abstract*—Flat slab are preferred by both architects and clients because of their artistic and economic rewards. This form of reinforced concrete construction gives more rewards over framed structure, they also gives some disfavor because of punching failure and larger deformation. Many researchers proposed that slab should be designed to resist only gravity loads when used in high seismic zones and lateral loads should be carried by lateral resisting system. The load transferred path changes due to the excision of beams. But, the safety of buildings is to be checked. But from the past history it can be concluded that the flat slab is very susceptible to criticism for earthquakes. The floor system resists the GL (DL and LL) acting on it and transmits this to the vertical frames of buildings. I this process, the floor system is subjected to flexure and transverse shear, whereas the vertical frame elements are subjected to axial compression, frequently coupled with flexure and shear. The floor also used as a horizontal diaphragms connecting together. Under the a tion of lateral loads, the floor diaphragms distribute the lateral load to the diff rent vertical frames and shear walls**

***Keywords*— Flat slab, Punching shear, Unequal span**

I. INTRODUCTION

The general frame construction uses columns, slabs and beams it may be possible to attempt construction without providing beams, this frame consist of slab and column without beams or a RC structure slab supported directly by columns without the use of beams. This type of slabs are called as flat slabs. The flat slab is having various shapes (rectangular/square). The design of flat slabs is regularize by the punching shear strength at failure. Flat slab system is very simple to construct and it requires the minimum building height for a number of stories.Flat slab are preferred by both architects and clients because of their artis ic and economic rewards. This form of reinforced concrete construction gives more rewards over framed structure, they also gives some disfavor because of punching failure and larger deformation. Many research rs proposed that slab should be designed to resist only gravity loads when used in high seismic zones and lateral loads should be carried by lateral resisting system. The load transferred path changes due to the excision of beams. But, the safety of buildings is to be checked. But from the past history it can be concluded that the flat slab is very susceptible to criticism for earthquakes. The floor system resists the GL (DL and LL) acting on it and transmits this to the vertical frames of buildings. In this process, the floor system is subjected to flexure and transverse shear, whereas the vertical frame elements are subjected to axial compression, frequently coupled with flexure and shear. The floor also used as a horizontal diaphragms connecting together. Under the action of lateral loads, the floor diaphragms distribute the lateral load to the different vertical frames and shear walls.

AIM & OBJECTIVE

Comparative study of analysis and design of flat slabs of unequal spans by using different standards

- Analysis and design of flat slab with unequal span for different codes like IS 456-2000, BS 8110, ACI-318.
- To understand the behavior of structures and their importance with respect to different codes.

II. LITERATURE REVIEW

Research work related to comparisons between structural codes is numerous in the available literature. Structural design codes have developed in India over 20th century and will continue to evolve as engineers' changes their way of designing and as they learn more about structural behavior, material strength, and the imposed loading In this chapter, it has been tried to understand the behavior of parameters such as shear force, bending moment, punching shear related to comparisons between equal and unequal span with respect to different code.

Contributions of researchers are presented as follows,

Krich Atchacosit[1] studied the comparison for beam reinforcement to be required by different international design code (American, British and Euro Codes) with the aim of determining which of the three codes provides the most economic design and he concluded that Euro code gives the lowest ultimate design loads due to partial factor of actions are lowest cause to the lowest of moment and shear force in beam. ACI requires area of tension reinforcements lowest. Euro code requires shear reinforcements lowest. BS8110 require curtailment of extra reinforcement although BS8110 requires area of tension reinforcement highest. Due to the theoretical of three codes require shear & tension reinforcement not significant different and the available on bar size, practical stirrup spacing be considered when detailing the beam cause to the rebar content of the three codes given similar.

Tabish Izhar and Reena Dagar [2] described the comparison of reinforced concrete member design methods of various countries concluded based on the results of the study it was concluded that flexural reinforcement is least from IS 456:2000 code and maximum for CSA A23.3 by keeping the live load, dead load and wind load same for all codes. Shear reinforcement for beams is least for IS456:2000 and is maximum for Canadian code. Longitudinal reinforcement for columns is minimum from EC and maximum for Canadian code. Longitudinal and transverse reinforcement for the slab is least for EC and maximum for ACI318. The difference in area of reinforcement is observed due to the difference in stress block diagrams of steel and concrete. This difference is due to difference in maximum strain in steel and concrete taken differently in various codes thus the formulas for calculating area of reinforcement is also different. Since for the combined effect of dead, live and wind load results are varying hence it is not easy to give the exact solution but efforts can be made further in this field to arrive at the best results.

S.S.Patil1 , Rupali Sigi[3] studied analysis and design of flat slabs using IS 456-2000, ACI 318-08, BS 8110-1997, EC2 Part I 2004 codes and concluded that ne ative & positive moments at exterior support is increases for IS 456-2000 as compared to (ACI 318-08, BS 8110-1997, EC2:Part1-2004) for Equivalent Frame Method. In exterior support, the total design moments (Mo) are distributed as 100% in column strip and 0% in middle strip in both the case IS 456-2000 and ACI 318-08 & the total design moments (Mo) are distributed as 75% in column strip and 25% in middle strip in both the case BS 8110-1197 and EC2- Part1-2004. In flat slab (with & without staggered column) in both cases the punching shear criteria is satisfy except Interior columns as per ACI 318-08 as compared to other code.

Sami W. Tabsh [4] described the comparison between reinforced concrete designs based o the ACI 318 and BS 8110 codes. he concluded that both codes closely predict the flexural capacity of singly-reinforced cross-section to within 4%. There were somewhat large discrepancies between the shear strengths obtained by the two c des. Except for very lightly transversely reinforced sections, the ACI code shear strength equations predicted 10-30% lower capacity than the corresponding equations in the BS code. As the longitudinal steel reinforcement ratio increases, the ACI code prediction of the axial compressive strength of concentrically loaded cross-sections decreases fr m 10 to 25% below the corresponding strength predicted by the BS code. The load combinations involving dead load, live load and wind in the ACI code yield larger factored loads, by up to 20%, than the corresponding combinations in the BS code, especially for small wind-to-dead load ratios. Since the ACI 318 code predicts a little lower structural strength while at the same time slightly overestimates the factored load effect, compared to the BS 8110 code, the net effect results in a larger overall factor of safety. This translates to somewhat larger cross-sections and/or more steel reinforcement, and consequently higher construction costs, for members designed following the ACI 318 code over corresponding members sized based on the BS 8110 code.

SIA KEE SIENG[6] studied comparative study of reinforced concrete design of column between American code (ACI 318-05) and British standard (BS 8110-97) he concluded that although the design process of ACT Codes is more technical but it is easy to understand because the design procedure is more details with the less of assumptions as compare to BS 8110. The result of the research was then show that the area of the required reinforcement of column while design using ACI Codes is almost similar with the column design in BS 8110.

DR.KN.KADAM,VIQUAAR SHAIKH[7] represented a numerical analysis of flat slab with different models. Without providing any shear reinforcement in the flat slab can be studied and compared among themselves.

Georgewill V.A., Ngekpe B.E., Akobo I.Z.S. and Jaja G.W.T.[8] reviewed punching shear failure of flat slab system. Firstly, the merits of flat slab system compared to normal framed structure were appraised. Due to complex mechanisms that occur during punching shear failure, it has been a subject of intense experimental, analytical and experimental investigations. This study focuses more on finite element.

N. Nguyen-Thanh a, Timon Rabczuk b, H. Nguyen-Xuan c, Stéphane P.A. Bordas d,[9] investigated the capability of the proposed calibrated concrete damaged plasticity model for punching shear simulations of reinforced concrete slabs. The chosen concrete damaged plasticity model is calibrated based on selected tests from literature. it is observed that the cracking propagation together with the load-deflection response of the slab should be taken into consideration for the adoption of the proper mesh size.

Ashraf Mohamed Mahmoud[10] concluded that punching shear reinforcement systems such as studs and stirrups are used to improve the punching shear strength of flat slabs. Several important parameters are incorporated in the analysis, namely the column size, the slab thickness and the punching shear reinforcement system in o der to study their effects on the flat slab behavior. A parametric study was carried out to look at the variables that can mainly affect the mechanical behaviors of the model such as the change of loading types and positions and slab with openings. Good correlation is observed between the results of the proposed model and other experimental one, resulting in its capability of capturing the fracture of flat slab under punching shear behavior to an acceptable accuracy.

III. THEORETICAL FORMULATION

Since the usage of foreign code such as ACI 318. BS8110 is getting common in India as more and more multi-national companies have opened there back end offices in India which has led to research on comparative study between various codes.

Current Problem formulation includes the behaviour of flat slab structures and their importance with respect to different codes for different spans. The structural modeling analysis procedure by software is also included in this chapter.

Components of flat slab design:

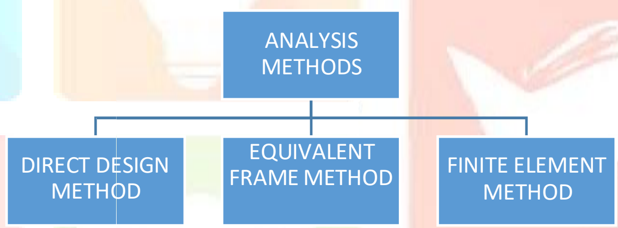
a) Column strip: Column strip means a design strip having a width of 0.25 L, but not greater than 0.25 L1, on each side of the column centre-line, where L, is the span in the direction moments are being determined, measured centre to centre of supports and L1, is the -span transverse to L measured centre to centre of supports.

b) Middle strip: Middle strip means a design strip bounded on each of its opposite sides by the column strip.

c) Panel: Panel means that part of a slab bounded on-each of its four sides by the centre -line of a Column or centre-lines of adjacent-spans.

e) Depth of flat slab: The thickness of the flat slab up to spans of 10 m shall be generally controlled by considerations of span (L) to effective depth (d) ratios given as below: Cantilever 7; simply supported 20; Continuous 26.

ANALYSIS METHODS.



The slab gives a flat surface and is normally upheld by slabs, bars or dividers. Slabs can be ordered into two principle types: single direction slabs and two-way slabs. Single direction slabs are upheld by two inverse sides and twisting happens one way in particular. Two-way slabs are upheld on four sides and bowing happens in two ways. Single direction slabs are planned as rectangular pillars put next to each other. In any case, slabs upheld by four sides might be expected as single direction slab when the proportion of lengths to width of two opposite sides surpasses 2. Despite the fact that while such slabs move their stacking in four ways, essentially all heap is moved the short way. Two-way slabs convey the heap to two headings, and the twisting second toward every path is not exactly the bowing snapshot of single direction slabs. Likewise two-way slabs have less diversion than single direction slabs. Contrasted with single direction slabs, Calculation of two-way slabs is more unpredictable. Techniques for two-way slab plan and investigation incorporate Direct Design Method (DDM), Equivalent frame method (EFM) and Finite element method.

This task expects to utilize quite possibly the main projects in the investigation and plan of solid Slabs, which is the (finite element) program for precision of the arrangement and the exactness of the outcomes given by finite element program package. A slab might be planned by any strategy fulfilling conditions for balance and mathematical similarity.

3.3.1 Equivalent frame method (EFM):

The ‘equivalent frame method’ of design (EFM is also called as Elastic Frame Method) of two-way beam-support slabs, flat slabs, flat plate and waffle slabs is a more general (and more rigorous) method than DDM, and is not subject to the limitations of DDM.

A concept simplifies the analysis of a three-dimensional reinforced concrete building by subdividing it into a series of two-dimensional (plane) frames (‘equivalent frames’) centered on column lines in longitudinal as well as transverse directions. The ‘equivalent frame method’ differs from DDM in the determination of the total ‘negative’ and ‘positive’ design moments in the slab panels — for the condition of gravity loading. However, the apportioning of the moments to ‘column strips’ and ‘middle strips’ (or to beam and slab) across a panel is common to both methods.

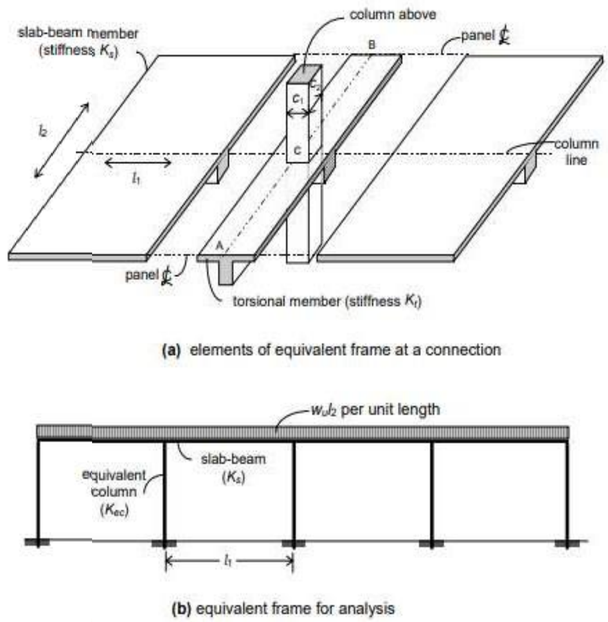


Fig.1 Equivalent frame method

The bending moments and shear forces in an 'equivalent frame' are obtained in EFM by an elastic analysis. Such an analysis should generally be performed on the entire plane frame. However, if the frame is subjected to gravity loading alone, a frame geometry and loading are not so unsymmetrical as to cause significant 'sway' (lateral drift) of the frame, each floor may be analyzed separately, considering the appropriate 'substitute frame', with the columns attached to the floor assumed fixed at their far ends. A urther simplification may be made for the purpose of determining the design moment at a given support or span in the slab-beam member, by assuming the slab-beam to be fixed at any support two panels distant, provided the slab is continuous beyond this point. The load transfer system in the 'equivalent frame' involves three distinct interconnected elements (Fig.1a):

- Slab-beam members (along span l1);
- Columns (or walls); and
- The torsion member, transverse to the frame (along span l2) and along the column lines.

3. The Direct Design Method (DDM) is a simplified procedure of determining the 'negative' and 'positive' design moments (under gravity loads) at critical sections in the slab, using empirical moment coefficients. In order to ensure that these design moments are not significantly different from those obtained by an elastic analysis, Code specifies that the following conditions must be satisfied by the two-way slab systems for the application of DDM.

1. There must be at least three continuous spans in each direction.
2. Each panel must be rectangular, with the long to short span ratio not exceeding 2.
3. The columns must not be offset by more than 10 percent of the span (in the direction of offset) from either axis between centerlines of successive columns.
4. The successive span lengths (centre-to-centre of supports), in each direction, must not differ by more than one-third of the longer span.
5. The factored live load must not exceed three times the factored dead load (otherwise, moments produced by pattern loading would be more severe than those calculated by DDM).

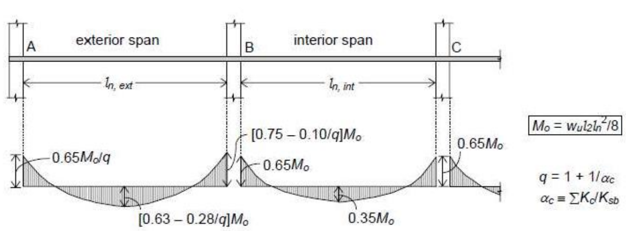


Fig.2 Distribution of total moment Mo into 'negative and positive' design moments (longitudinal)

The IS code recommendation for the distribution of the calculated 'total design moment', Mo, between critical 'negative' moment sections (at the face of equivalent rectangular supports) and 'positive' moment sections (at or near mid span) is as depicted in Fig.2.

Interior span:

∗ 'negative' design moment Mo − = 0.65Mo

∗ 'positive' design moment Mo + = 0.35Mo

Exterior span:

∗ 'negative' design moment at exterior support = (0.65/q)M.

∗ 'negative' design moment at interior support= (0.75 – 0.10/q)Mo

∗ 'positive' design moment M = (0.63 – 0.28/q)Mo

where q ≡ 1 +1/ αc

αc ≡ (Σ Kc/ Ksb)

Σ Kc ≡ sum of flexural stiffnesses of columns meeting at the exterior joint; and

Σ Ksb ≡ flexural stiffness of the slab (or slab-beam members)in the direction moments are calculated (i.e., along span l1), at the exterior joint

3.2 Direct design method (DDM):

It is an estimated semi-observational method for breaking down two way slab frameworks. It applies to slab upheld by pillars or dividers, level slab, level plates and waffle slabs. The code gives a methodology which a bunch of second coefficients can be resolved. The strategy, basically, includes a solitary cycle second circulation examination of the construction dependent on (a) the assessed flexural firmness' of the slabs, radiates (assuming any), and slabs and (b) the tensional solidness' of the slabs and bars (assuming any) cross over to the heading where flexural minutes are being resolved. A few sorts of second coefficients have been utilized agreeably for a long time for slab plan. They don't, nonetheless, give extremely good outco es for slabs with unsymmetrical measurements and stacking designs. Direct Design Method (DDM) for slab frameworks with or without radiates stacked simply by gravit stacks.

3.3.1 FINITE ELEMENT METHOD

Finite element method use to solve the complex elasticity problems. It subdivides a large system into smaller, simpler parts that are called finite elements.

FEM has become very familiar in sub division of continuum; it gives reliable and accurate results if the number of elements are kept greater.

Modern computer technology has helped this analysis to be very easy and less time consuming.

Large structure under loadings are now easily solved and stresses on each and every part are now being determined.

In this method ,the structure to be analyzed is subdivided into a mesh of finite sized elements of simple shape and the whole structure is solved with quite easiness.

There are one two and three dimensional elements. The accuracy of the solution is depends upon the number of element ,the more there are, the greater the accuracy.

3.4 Comparison of methods

The Direct Design Method and the Equivalent Frame Method for gravity load analysis differ essentially in the manner of determining the distribution of bending moments along the span in the slab-beam member (Fig.1a). The former uses moment coefficients (similar in concept to the simplified Code procedure for continuous beams and one-way slabs), whereas the later requires an elastic partial frame analysis. The procedure for apportioning the factored moments between strip and the column strip (or between the slab and the beam when beams are present along the column line) is identical for both design methods.

Both methods require the values of several relative stiffness parameters in order to obtain the longitudinal and transverse distribution of factored moments in the design strips. For this purpose, as well as for determining the dead loads on the slab, it is necessary to assume, initially, the gross section dimensions of the floor system (and the columns). These dimensions may need to be modified subsequently, and the analysis and design may therefore need to be suitably revised.

3.4 LOADING CONDITIONS.

The following are the set of loads considered (loads are kept constant to compare various design as per various design codes).

1. Typical imposed load 3kn/m2
2. Floor finish 2.5kn/m2 including weight of partition walls

IV. PROBLEM FORMULATION

The problem is defined in previous chapters along with loading conditions prescribed in chapter three. The flow and methodology of the research work related to different cases of various span with respect to different codes for particular loading condition is discussed in the current chapter

Flow of Research

Philosophy of various standards:

The three codes are compared in the context of design of primary structural elements. Knowledge must be extended to cover the whole aspects of each part, as well as, the economical and the conservative results

2-1 Loading

The three codes impose partial factors of safety for loads due to design assumptions and inaccuracy of calculation, possible unusual load increases, and constructional inaccuracies.

Design load=characteristic load* partial load factor of safety (γ).

The value of this factor f γ takes into a count the importance of the limit state under consideration and reflects to some extent the accuracy with which different types of loading can be predicted, and the probability of particular load combinations occurring. Table (1) illustrates the values of partial factors of safety for the loadings, and a basic load combination stipulated by the three codes[1, 2, 3] .

Code	Dead Load	Live Load
ACI318	1.2	1.6
BS8110	.4	1.6
IS456	.5	1.5

Table 1 Partial safety factors for Basic Load combinations at ultimate limit state.

Both (γ dead) and (γ live) are marginally in ascending and descending manner from ACI-318 reaching to the highest and lowest values in IS456.

2-2 Materials

As in BS8110, IS456 uses a basic material partial factor of safety (γ m):

Design strength = characteristic strength Design strength / material partial factor of safety γ m

The strength of the material will differ from that measured in a carefully prepared test specimen and it is particularly true 3-1 Design Criteria

The balanced beam in ultimate strength design is fundamental to the philosophy of all the considered three codes. The Codes limit the tensile reinforcement to a maximum value must be less than the balanced reinforcement area. ACI code limits the tensile reinforcement to a maximum of 0.75ρb, while BS8110 and EC2 limit i to 0.76ρb and 0.53ρb* respectively [1, 2, 3]

6. Conclusions The main conclusions from this study can be summarized as follow: 1. Although the principles contained in the considered building regulations are generally the same, they differ in details. 2. In general EC2 and BS8110 are not very different from ACI Code in terms of the design approach. They give similar answers and offer scope for more economical concrete structures. 3. A true factor of safety can only be determined by comparing design loading with that at collapse. While partial safety factors for materials and loadings are not safety factors; they only reflect degrees of confidence in material properties and accuracy of load prediction. 4. EC2 and ACI Code are more extensive for design requirements point of view than BS8110. For example in permitting using higher concrete strength. 5. After study some numerical examples; EC2 and BS8110 show close agreement in flexure plus axial compression results, while ACI Code results diverge in a less economical side. 7. BS8110 exhibits larger allowable design shear strength of concrete. 8. ACI

Code, EC2, and BS8110 give a very close design moment capacity for steel ratios within or less than balanced steel ratio. But EC2 is more generous in doubly reinforced sections

4.4 Flow of work:

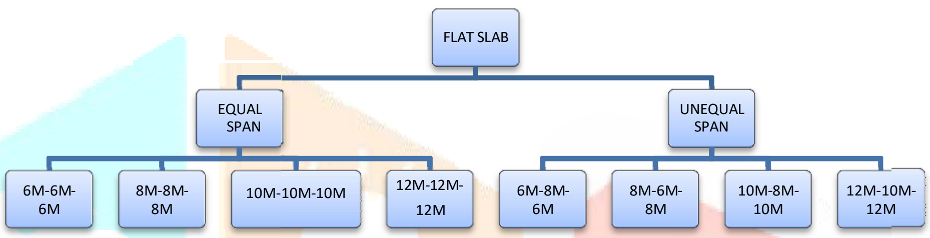


Figure No. 4.1 Cases considered

In Research Methodology, various span with various codes are considered for particular loa ing condition.

In the current project the work is follo s as per the flow shown in previous section. the very first step in the design of flat slab is to work out the geometry of the cross section of the flat slab. the cross section of flat slab is governed by punching shear ratio, considering cross section required for punching shear ratio tables and charts are developed for various spans & codes of end strip and interior strip. The details of tables and charts are given in Appendix A.

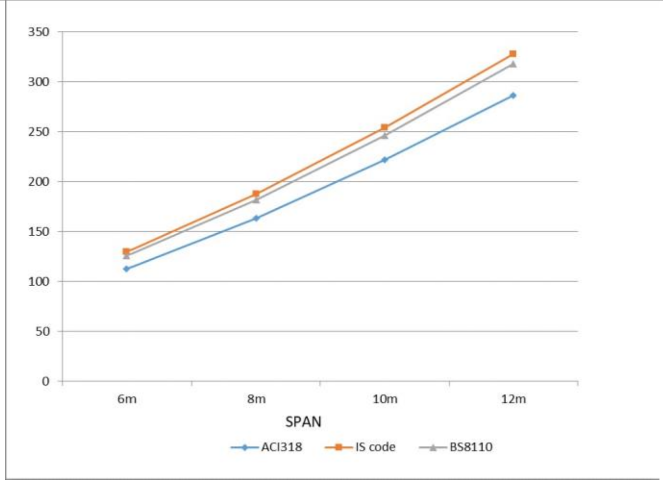
4.4 Analysis of flat slab for equal and unequal spans using software.

Finalized equal and unequal spans for various codes are analysed using finite element package.

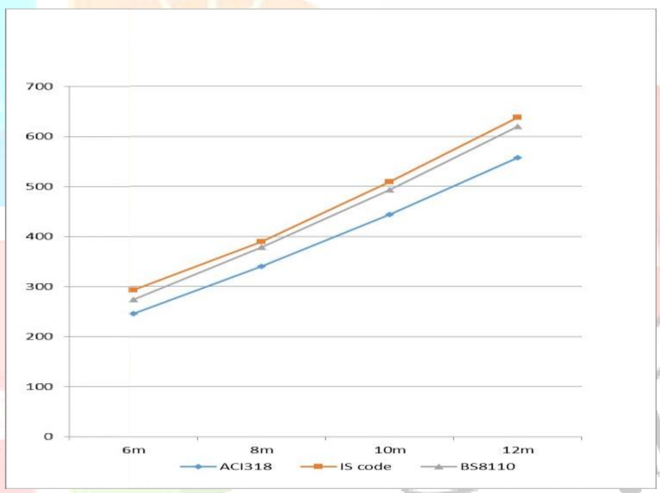
V. RESULTS

The current project work is to comparative study of equal and unequal span with respect to different codes as per flow of project mentioned in the previous chapter. Flat slab with equal and unequal span with respect to different codes are designed governed by various parameters calculated using tables. The result values of various parameters with different codes are solved using finite element package. Maximum and minimum of the forces and maximum punching ratio are obtained for each case; the non-dimensional variations are plotted and discussed in the current chapter.

5.2.1 Effect of equal span on shear force for various standard.



G1- variation of shear force against span for various method and for various spans in end strip



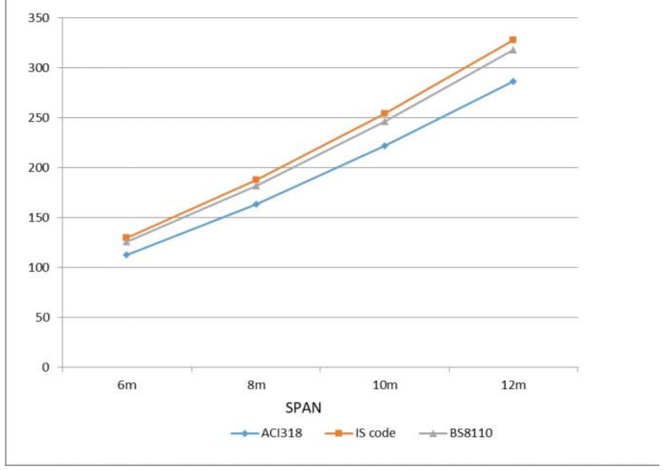
G2- variation of shear force against span for various method and for various spans in interior strip

OBSERVATIONS:-

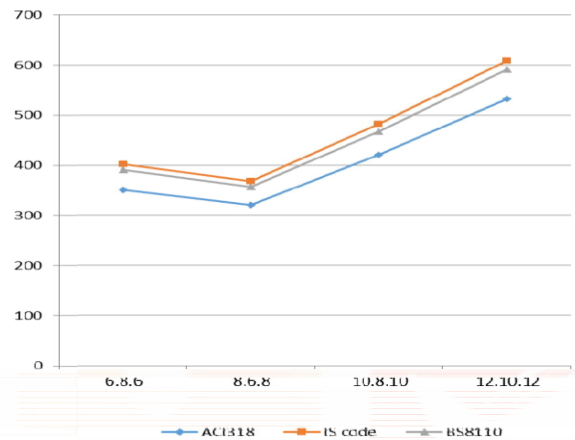
From the above graph following points are noted.

- As span of equal span case of flat slab increases shear force increases.
- The variation of shear force increases as span length increases for higher span.ACI standard gives the comparatively lower results with respect to BS and IS.
- IS standard gives highest values in all cases of shear force for equal span end strip results.
- The IS results of shear force for equal span case of flat slab are almost 8% more than other standards.

5.2.2 Effect of unequal span on shear force for various standard.



G3- variation of shear force against span for various method and for various spans in end strip



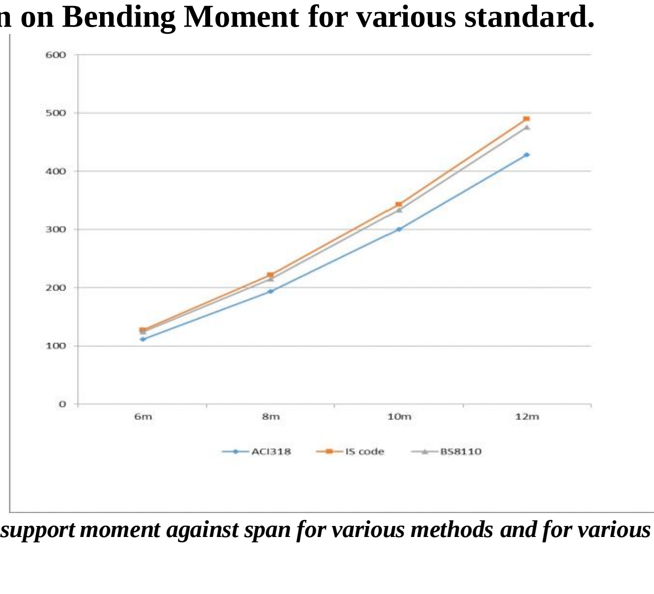
G4- variation of shear force against span for various method and for various spans in interior strip

OBSERVATIONS:-

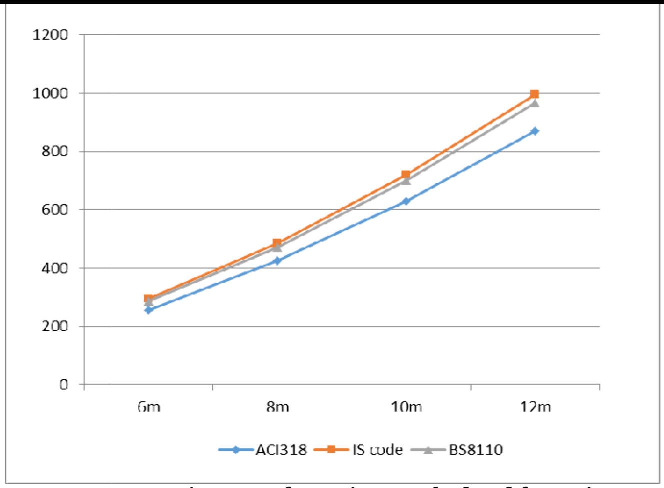
From the above graphs following points are noted.

- As span of unequal span case of flat slab increases shear force increases.
- The variation of shear force increases as span length increases for higher span.
- ACI standard gives the comparatively lower results with respect to BS and IS.
- IS standard gives highest values in all cases of shear force for equal and unequal span end strip re ults.
- The IS results of shear force for equal and unequal span case of flat slab are almost 13% more than other standards.

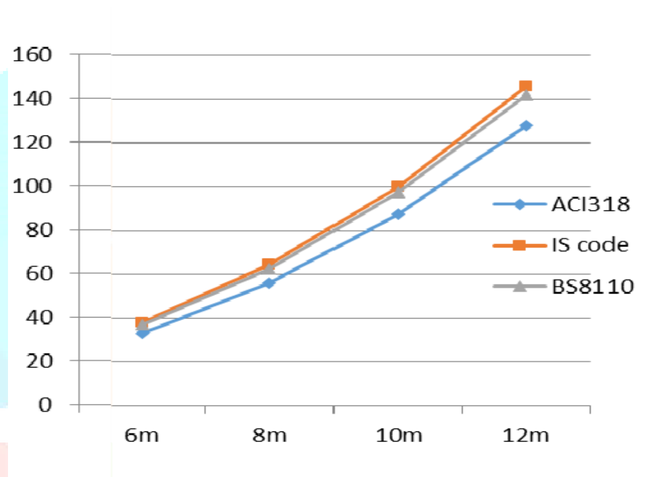
5.3.1 Effect of equal span on Bending Moment for various standard.



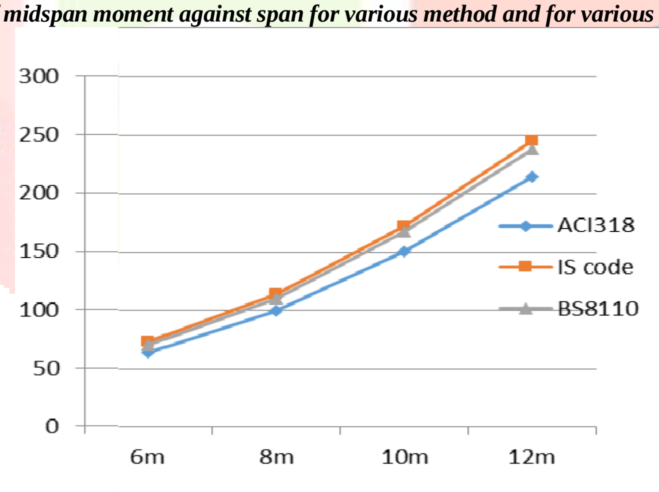
G5- variation of support moment against span for various methods and for various spans n end strip



G6- variation of support moment against span for various method and for various spans in interior strip



G7- variation of midspan moment against span for various method and for various spans in end strip

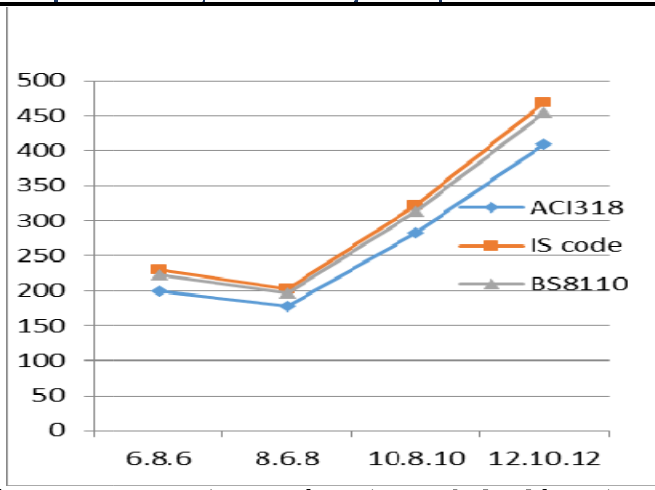


G8- variation of midspan moment against span for various methods and for various spans in interior strip

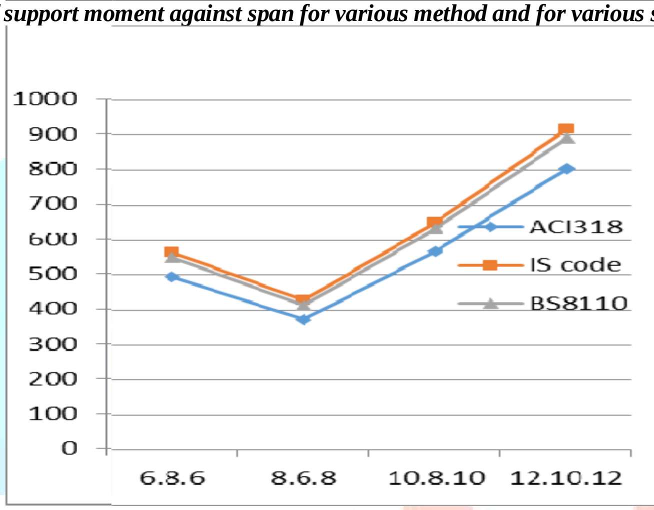
OBSERVATIONS:-

- From the above graph following points are noted.
- The variation of Support and mid span moment increases as span length increases for higher span.
- ACI standard gives the comparatively lower results with respect to BS and IS.
- IS standard gives highest values in all cases of support and mid span moment for equal span strip results.
- The IS results of support and mid span moment for equal span case of flat slab are in the range of 8 to 12% more than other standards.

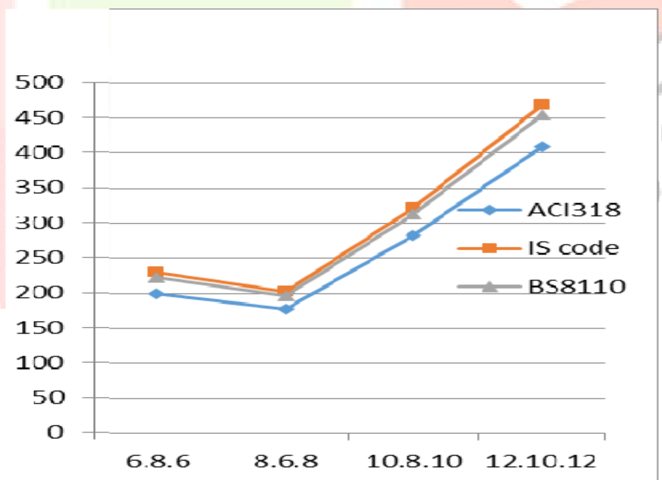
5.3.2 Effect of unequal span on Bending Moment for various standard.



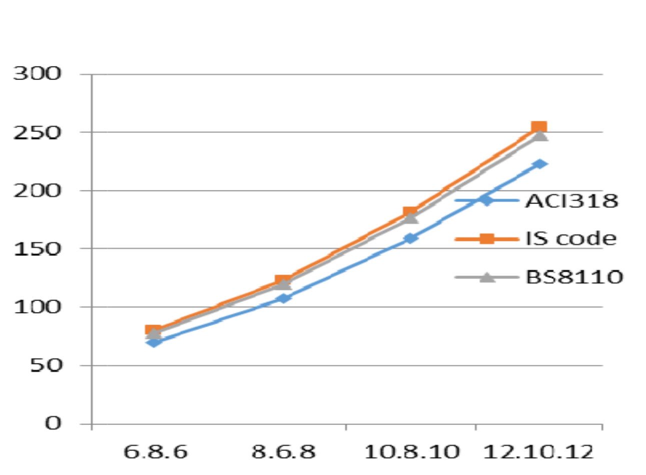
G9- variation of support moment against span for various method and for various spans in end strip



G10- variation of support moment against span for various method and for various spans in interior strip



G11- variation of midspan moment against span for various method and for various spans in end strip

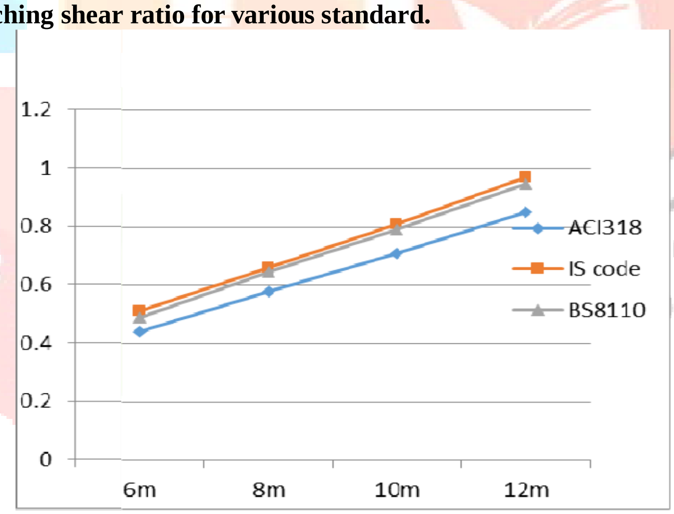


G12- variation of midspan moment against span for various method and for various spans in interior strip

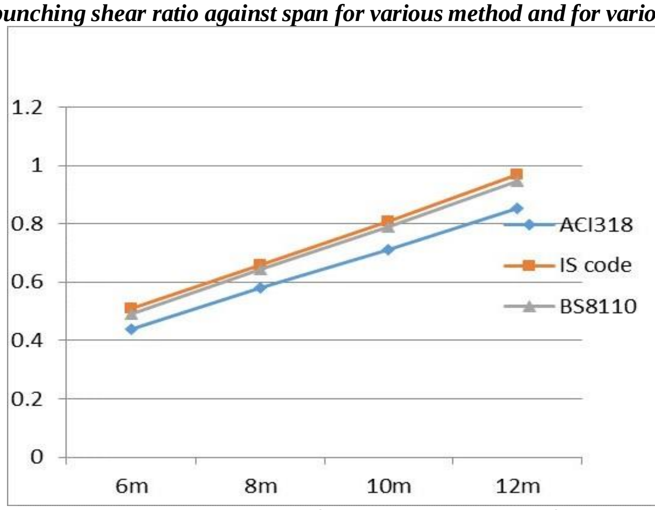
OBSERVATIONS:-

- From the above graph following points are noted.
- Larger length of internal span gives the higher support moment at support than smaller internal span of unequal span case of flat slab.
- The variation of support and mid span moment increases as span length increases for higher span.
- ACI standard gives the comparatively lower results with respect to BS and IS.
- IS standard gives highest values in all cases of support and mid span moment for unequal span strip results.
- The IS results of support and mid span moment for equal and unequal span case of flat slab are almost 12% more than other standards.
- There is no effect of smaller internal span for reducing mid span moment in unequal span. case o flat slab.

5.4.1 Effect of equal span on Punching shear ratio for various standard.



G13- variation of punching shear ratio against span for various method and for various spa s in end strip

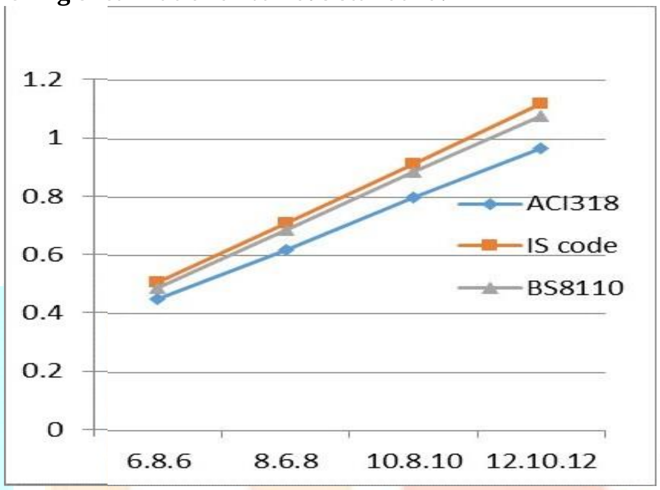


G14- variation of punching shear ratio against span for various method and for various spans in interior strip

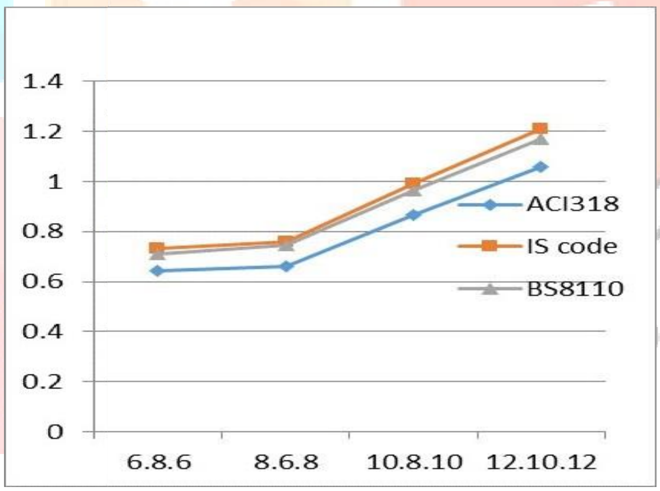
OBSERVATIONS:-

- From the above graphs following points are noted.
-
- Punching shear ratio for IS and BS is aln ost same in equal span case of flat slab.
- The Punching shear ratio increases as span length increases for higher span.
- ACI standard gives the comparatively lower results with respect to BS and IS.
- IS standard gives highest values in all cases for punching shear ratio for equal span strip results.
- The IS results of punching ratio for equal span case of flat slab are almost 11% more than ACI standard.

5.4.2 Effect of unequal span on Punching shear ratio for various standard.



G15- variation of punching shear ratio against span for various method and for various spa s in end strip



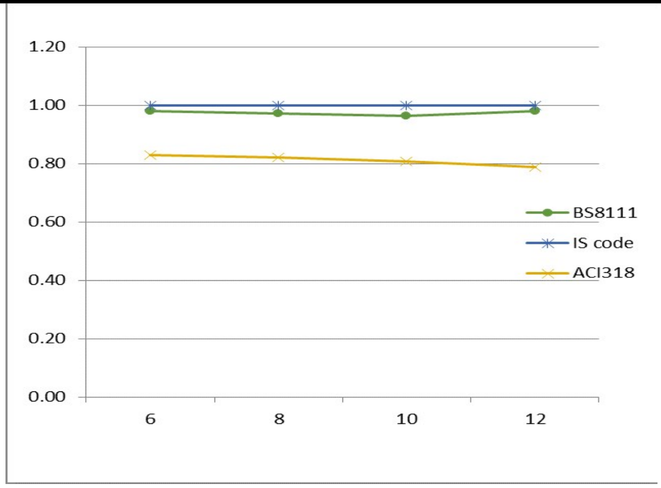
G16- variation of punching shear ratio against span for various method and for various spans in interior strip

OBSERVATIONS:-

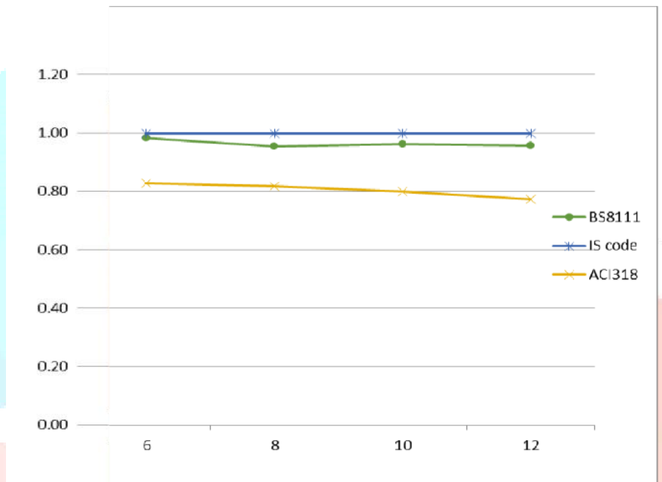
From the above graphs following points are noted.

- Smaller length of internal span gives higher punching shear ratio at end as well as interior strip than larger internal span of unequal span case of flat slab for all the standards.
- Punching shear ratio variation increases as span length increases for higher span.
- BS and IS. Results are comparatively higher than ACI standard.
- IS standard gives highest values in all cases for punching shear ratio for unequal span end strip results.
- The IS results of punching ratio for equal and unequal span case of flat slab are almost 5 to 12% more than other standards

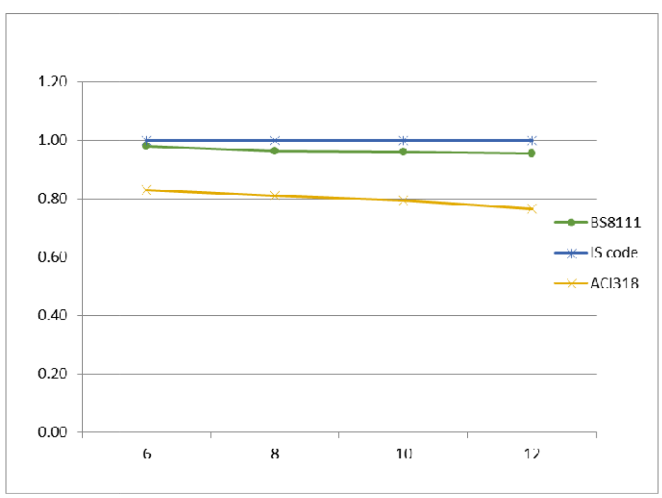
5.5.1 Variation of steel ratio of equal span for various standard.



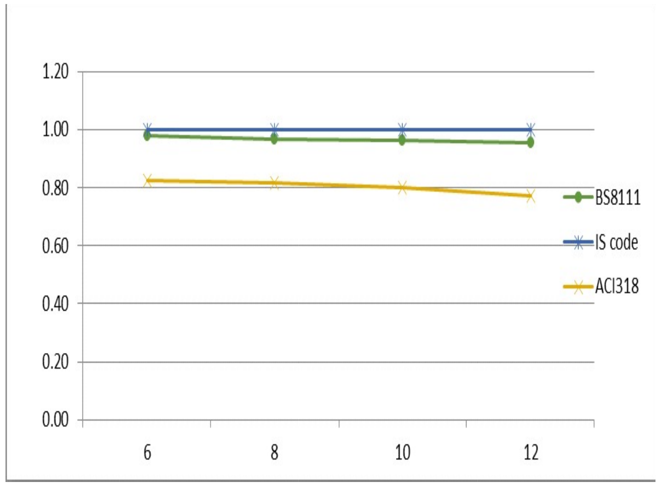
G17- variation of top steel quantity against span for various method and for various spans in end strip



G18- variation of bottom steel quantity against span for various method and for various spans in end strip



G19- variation of top steel quantity against span for various method and for various spans in interior strip



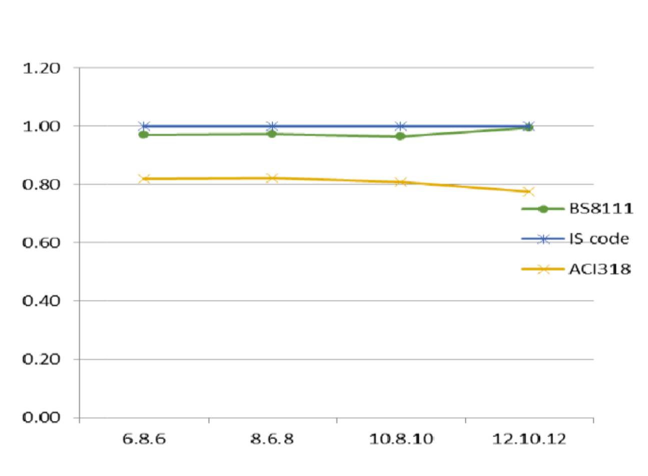
G20- variation of bottom steel quantity against span for various method and for various spans in interior strip

OBSERVATIONS:-

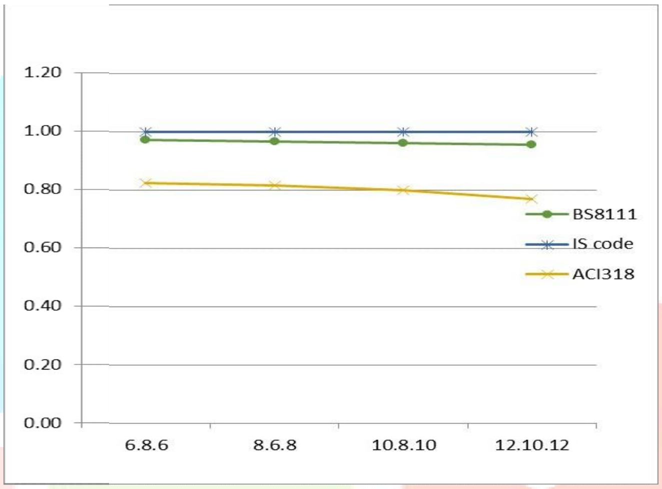
From the above graphs following points are noted.

- The steel percentage from IS and BS for equal span gives almost near by value for top steel at end strip interior support than ACI standard.
- The variation of steel percentage increases as span length increases for higher span.
- Percentage of steel ratio is lower for AC standard than BS and IS standard.
- Highest steel percentage ratio in all cases top steel for equal span strip result can be seen for IS standard.
- The IS results of top steel percentage for equal span case of flat slab are almost 18% higher than CI standard.

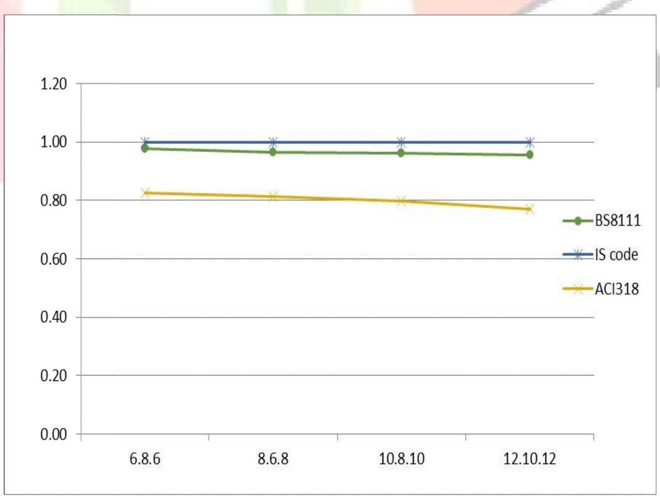
5.5.2 Variation of steel ratio of unequal span for various standards.



G21- variation of top steel quantity against span for various method and for various spans in end strip



G22- variation of bottom steel quantity against span for various method and for various spans in end strip



G24- variation of bottom steel quantity against span for various method and for various spans in interior strip

OBSERVATIONS:-

From the above graphs following points are noted.

- The variation of steel percentage increases as span length increases for higher span.
- ACI standard gives the comparatively lower percentage of steel with respect to BS and IS.
- IS standard gives highest steel percentage in all cases bottom steel for unequal span strip result.
- The IS results of bottom steel percentage for unequal span case of flat slab are almost 22% more than ACI standard.

VI. CONCLUSIONS

- The use of different codes on various equal and unequal span gives significant results from different structural aspect. The effect of variation of equal and unequal span and different codes on end strip and interior strip is observed through shear force, maximum bending moment, punching shear ratio and area of steel required.
- For equal spans all parameters such as Shear force, Bending moment and Punching shear ratio increases.
- For unequal spans parameters such as Shear force, Bending moment and Punching shear ratio are depend upon the nature of internal span. Smaller internal span gives higher values than bigger internal span.
- ACI standard gives the comparatively lower results with respect to BS and IS for various parameters considered for flat slab analysis.
- IS standard gives highest values in strip results for all cases of equal and unequal spans flat slab.
- The results values of parameters using IS standard are almost 8 to 15% on higher side comparatively to the other standards.

A-E QUAL SPAN CASE

1. **SHEAR FORCE**

- The variation of shear force increases as span length increases for higher span.
- The IS results of shear force for equal span case of flat slab are almost 8 to 13% higher than other standards.

2. **BENDING MOMENT**

- As span of equal span case of flat slab increases Bending moment increases gradually
- Bending moment at support is almost 3 times the bending moment at midspan.
- The variation of Bending moment increases as span length increases for higher span.
- The IS results of bending moment for equal span case of flat slab are almost 15% higher than CI standard.

3. **PUNCHING SHEAR RATIO**

- The variation of punching shear ratio increases as span length increases for higher span.
- The IS results of punching ratio for equal case of flat slab are almost 11% more than other standards.

4. **AREA OF STEEL REQUIRED**

- The steel percentage from IS and BS for equal span gives almost nearby value for top steel for end strip and middle support than ACI standard.
- The variation of steel percentage increases as span length increases.
- The IS results of steel percentage for equal span case of flat slab are almost 15% more than ACI standard.

B-UNEQUAL SPAN CASE

1. **SHEAR FORCE**

- As span of unequal span case of flat slab increases shear force increases.
- The variation of shear force increases as span length increases for higher span.
- The IS results of shear force for equal and unequal span case of flat slab are almost 6 to 12% more than other standards.

2. **BENDING MOMENT**

- Larger internal span gives the higher moment at support than smaller internal span of unequal span case of flat slab.
- The variation of moment increases as span length increases for higher span.
- The IS results of moment for unequal span case of flat slab are almost 14% more than ACI standard.

3. **PUNCHING SHEAR RATIO**

- Bigger length of internal span gives almost nearby value of punching shear at end strip interior support than smaller internal span of unequal span case of flat slab for all the standards.
- The punching shear ratio increases as span length increases for larger span.
- The IS results of punching ratio for unequal span case of flat slab are almost 11% more than ot er standards

4. AREA OF STEEL REQUIRED

- Steel percentage increases with variation as span length increases for larger length spans.
- The IS results of top steel percentage for unequal span case of flat slab are almost 18% more than ACI standard.
- Variation from different point of view plotted in the previous chapter observations are noted with the variations. From these variations following conclusions are made for different parameters.

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