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The behaviour of reinforced concrete skew slab under static and blast loads an analytical study

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ABSTRACT

There has been a tremendous growth in the construction of important structures using the implementation of skew slabs in the last few decades. Especially in urbanized and developed areas where availability of space is a larger constraint and in grade separators or interchanges skew slab bridges are preferred over conventional rectangular slab bridges. The load distribution in skew slabs is entirely different and more complex compared to that in conventional rectangular slabs. The present investigation focuses on studying various effects of static and blast loads on reinforced concrete skew slab considering the load distribution and the influence of skew angle. The behavior of conventional slab against these loads are considered and taken as the reference. The extent of variation from the behaviour of conventional slabs is explained and the influence of skew angle is discussed. The displacement and stress parameters are analyzed under these loading conditions, along the length of the specimens and with respect to time to identify the static and dynamic behavior of conventional and skew slabs. The effect of skew angle is also studied by analyzing slab models with varying skew angle.

INTRODUCTION

The construction of skew slabs was not acknowledged as a special case in the earlier times. Performing the process of adopting design factors of conventional straight slab bridges for analysis, the skew slab bridges were constructed. No specific design parameters were considered regardless of the skew angle magnitude during analysis or design phase of the skewed slab bridges. Several theories were put forward arriving at conclusions in the load distribution patterns followed in a slab that is skew. It is also well acquainted with the fact that load path followed in a skew slab usually tends to orient as a shortcut to slab's obtuse corners. The modification to conventional slabs in the form of skew angle significantly influences the magnitudes of various stress resultant parameters also. These studies opened a wide area for the researchers to arrive at a conclusion that the skew slab is also a structural component that has to be designed and constructed taking unique measures and analyses. The behavior of the skew slab varies to that extent where torsional moments take fair role to play near by the obtuse corners and simultaneously the longitudinal moment is observed to get decreased when compared to the case of conventional right slabs. The increase in transverse moment and the concentration of reaction forces along with longitudinal negative moments at the obtuse corners is experienced. Besides these, at the acute corners the small reactions and the possibility of uplift reaction forces are also observed while analyzing. Also, for large skew angled slabs, reduction in longitudinal moment and increase in torsion moment at the obtuse corner with transverse bending in the deck is predicted by analysis. These peculiar characteristics make the

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skew slab structure more complex while analyzing, designing and construction than a conventional right slab structure. Fig 1.2-3 is a representation of load distribution in skew slab.

AIMS AND OBJECTIVES

The work majorly tries to focus on the response of reinforced concrete skew slab to static and blast loads. As per the available literature, exclusive and specific researches on this topic are limited. To perform the non-linear analysis of this structural component, an effective finite element software tool is required and in the present study. Abaqus 6.11 is the software that has been chosen to perform the activity. Desired three-dimensional modelling is expected to be done and proper validation of results using the available data from previous studies is proposed. The major objectives of the study are:

- To model conventional and skew reinforced concrete slabs loaded by uniformly distributed static and blast loads and compare the behaviours of the slab structures by obtaining the displacement and stress parameters.
- Model reinforced concrete skew slabs of different skew angles loaded by static and blast loads and compare their behaviours to study about the impact of skew angle in the behaviour of skew slab.
- Prepare the displacement and stress parameter characteristics in each loading case to find out the extent of variation shown by the reinforced concrete skew slab from the behaviour of conventional slab.

LITERATURE REVIEW

The audit of writing is relating to a portion of the imperative articles and review recorded by different specialist in their journals

Patrick Theoret et al. [20] have made their inputs in this field conducting research on analysing and designing both straight and skew slab bridges. Conventional analysis was done and they used equivalent- beam method to determine bending moments and shear forces required for designing concrete slab bridges which are skew.

Valentin Quintas [11] studied about the different methods in the yield line analysis of the slab structure and involved in checking the results of provided by all existing methods. He proposed two methods for performing yield line analysis and thereby facilitating a general comprehension of the general modes of failures in slabs. The ‘normal moment method’ being one of those methods was found to be the adequate method for correct yield patterns by curved or straight lines. The ‘skew moment method’ is suggested when the condition of no twisting moments is applied.

A. R. Cusens and I. I. Besser [1] shown interest in studying the load distribution in simply supported skew bridges. They have conducted experiments to examine the flexural behaviour of a skew slab mainly focussing on the bending and twisting moments also reactive and shearing forces under point loads. The tests were done on a simply supported asbestos- cement slab, 450 skew angle.

METHODOLOGY

Numerical simulation and modeling of reinforced concrete structures has been a vibrant research area for structural engineers in last couple of decades. Computer-aided analysis of concrete structures using finite element methods opened gate for various researches in this field and even complex and unconventional structures were modeled and tested for various loading combinations. The popularity of this method increased due to the ease in access of the results which are of ample accuracy. Since the earlier decades of the second half of twentieth century, finite element analyses of reinforced concrete structures had witnessed some remarkable advancement. Many researchers have made valuable contributions in understanding the behavior of even complex structures and developed sophisticated methods of analysis. A successful numerical simulation demands selection of suitable element, formulation of proper material model and selection of proper solution method. The basic description of the structure, which is to be modeled for finite element analysis and the entire process of modeling the structural component along with all modules of performing the analysis is detailed in this chapter. Analysis of the skew slab under

various loading conditions is done also the effect of skew angle in response of the structure is tested by modelling slabs with skew angles 200, 400 and 600. The problem when skew slab is subjected to blast loading is rather new and the advancements in researches related to this topic are still in embryonic stage.

RESULT AND DISCUSSION

General

The results obtained after performing the analyses of the structures on unit uniformly distributed and blast loads is discussed in this chapter. The work has been done to compare the responses of a conventional right-angled slab and a skew slab with a defined skew angle when they are subjected to static (udl) and dynamic (blast) loads. The behaviour of skew slab is identified and the results are compared with that of conventional slab. Also, the effect of skew angle on the behaviour of the slabs is also studied when the structure is subjected to both static and dynamic loads.

Response of Structural Components to Static Load

The behaviour of a conventional reinforced concrete slab, fixed at both ends and specifications described in the previous chapter was studied when it is subjected to a uniformly distributed load of 1 kN/m2. The responses are noted down and the variation of stress characteristics were plotted against the true length of the specimen. Parameters like deflection, equivalent stress on the structure, stress along the axial direction and reaction forces were plotted. The same procedure is carried out for a predefined slab with a skew angle of 200 and the same dimensions, fixed at both the ends. The results are then compared to arrive the extent of variation shown by skew slab from that of a right-angled slab. Graphs are plotted to understand the change in behaviour when the slab is distorted by a skew angle. For the derivation of the plots, paths are identified and selected along the longer span of both the slabs. All the graphs are plotted in Origin Pro 8.0, individually and the results are compared to arrive at valid conclusions.

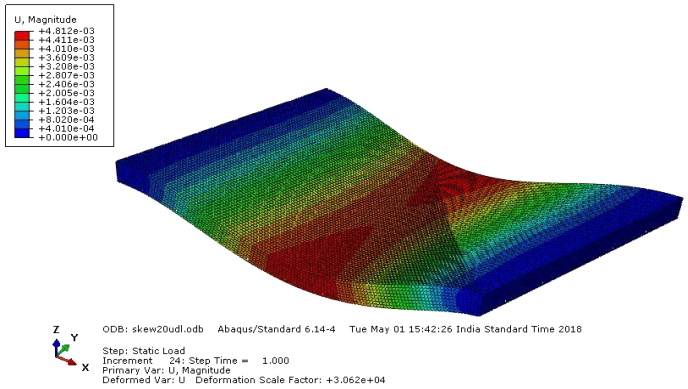

Fig: Displacement contour of skew slab subjected to a udl of 1kN/m2

Distance along the longer span (mm)	**Reaction Forces (mm)**			
	Conventional Slab (Skew angle 00)	Skew slab - I (Skew angle 200)	Skew slab- II (Skew angle 400)	Skew slab- III (Skew angle 600)
0	6.27405	5.25455	3.79304	1.73694
1200	6.27413	5.04097	3.52146	1.53319

The reaction forces are found to be greater in the case of conventional slab since the geometry and arrangement is linear and symmetric. At the same time, reaction forces are not equal at both ends of the skew slab if a path, parallel to the long span is selected for analysis. Value of reaction in case of conventional slab is 6.274 N. In case of skew slab-I, it is 5.254 N and 5.041 N since the path selected is not perpendicular to the skew span. For skew slabs II and III, the values are 3.793 N, 3.521 N and 1.736N, 1.533N respectively. Since it is not the symmetric axis, values are found to be different. Still there is a reduction of 17-20 % in the values when the skew angle is 200. For 400 and 600 skewed slabs, the reduction in reaction forces is 40-44% and 72-76% respectively.

The variation of parameters with respect to space i.e. distance has been studied and most of the parameters in case of skew slabs have shown wide range of variation from the behaviour of conventional slab. Thereby it is established that the skew angle plays a pivot role in the behavioral variations of the structure. The load distribution, deflection characteristics, stress distribution and reaction forces are majorly affected by the implementation of skew angle on a slab. The problem arises at the obtuse corners where stress concentration may take place, but still very few elements are subjected to that. The effect of skew angle in the static response of skew slab is therefore a major aspect to be considered while performing the analysis.

CONCLUSION

In the present scenario, the construction of important structures with skew slab as the major structural unit has become more popular and therefore the work done on the static and dynamic analysis of the structure is found to be relevant. As there were no guidelines available for the blast load analysis of skew slab, an attempt has been made to derive the comparison between conventional and skew slabs of different skew angles when these loads are applied to the structure. Also, it is found that the effect of skew angle in the behaviour of skew slab is very significant. It has been done first to study the different guidelines of all existing codes for analytical method and researches on this area. For this investigation a practical model is chosen of known height. The slab is considered as two- way slab in nature. The conventional and skew slabs are subjected to uniformly distributed load and blast load and are analyzed to arrive different stress and deflection parameters to understand the behaviour of skew slab and the effect of skew angle in it. From the previous literatures, and present work of analysis results, the following conclusions may be drawn:

- The extent of variation in the behaviour of skew slabs from that of conventional slabs is very high when subjected to static loads. The deflection values are found to be high in the case of conventional slabs subjected to udl. A reduction of 20% is found when skew slab is subjected to the same load.
- Skew slabs possess lesser values in deflection, equivalent stress, axial stress when compared to that of conventional slabs. The value gets lesser as the skew angle is increased and the characteristics is deviated away from that of conventional slab.
- The reaction forces have been found to get reduced when skew slabs are adopted against conventional slabs. The reduction increases when the skew angle is also increased.
- The variation is experienced in the case of static analysis of the structures. When the stress and deflection parameters are plotted against time, i.e. in the case of application of blast load, comparatively lesser variation in behaviours are found between skew slabs and conventional slab.
- Stress concentration is high in at least some elements at the obtuse corner of skew slab and it gets increased as the skew angle is increased. Therefore, slabs with skew angle lesser than 400 can be implemented as the replacement of conventional slabs.
- The effect of dynamic loads cannot be studied and concluded with only the time variant parameters, detailed analysis is required and advanced software is suggested to perform that.

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