COMPARATIVE STUDY OF STAIRCASE WITH VARIOUS SUPPORT CONDITIONS USING STAAD.PRO

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Abstract - *Staircase is very basic piece of a building yet it isn't given obvious consideration, to the extent its real conduct is worried, in different driving codes of training. In our Indian code of training IS 456:2000, the proposals with respect to the traverse of stair sections are restricted just to indicate powerful traverse for the stair where the arrival is end bolstered spreading over toward flight or landing(s) upheld at right point to the bearing of flight. The present report tries to discover the conduct of stair section display hypothetically utilizing limited component strategy for a given arrangement of limit condition. Analytical results of bending moment and deflection of stair slab, have been compared with six different support types (CASE I to CASE VI), using STAAD.Pro.. Variation in moments and deflections at critical locations, along the stair slab model has been presented in the graphical form. It is also found from the analysis that the stair slabs with landings supported on the different support arrangements behave differently and the specifications available as per Indian Code may not be applied uniformly to different support arrangements. Significant restraining effect has been seen due to additional supporting arrangements. However, the above findings need to be validated through experimental studies so as to enhance the understanding of their true behavior and use in rational design.*

Key Words: **Staircase, Building, Bending Moment, Deflection, Bolstered Spreading, STAAD. Pro.**

1.0 INTRODUCTION

Staircase is utilized as a part of structures for giving access to person on foot to various floors and top of a structure. These are planned as chunk upheld on the bars or dividers or casing structure at edges of arrivals. The plan is by and large in light of the rules by various codes of works on, considering no uncommon treatment for changing help conditions and state of the stair chunk. Extraordinarily, the conduct of doglegged stair has not been surely knew because of coherence of the material in two ways in the arrivals and the average network at the intersection of midriff sections and the arrivals. Singular endeavors made by couple of specialists assert intense change in the conduct because of shifting help conditions and the determinations gave by codes of practices discovered lacking for the planners to help in balanced outline of stair sections of various kinds. The genuine conduct of the stair chunk might be set up by thorough hypothetical investigation for various help conditions and the trial tests directed on full scale or model staircases. Anyway the present examination is limited to the hypothetical examinations for doglegged stair for few chose bolster conditions.

1.1 Schematic View of Staircase

Staircase comprises of for the most part two sections, to be specific flight and landing. Arrangement of steps are given in the flight. The vertical stature of the progression is called riser and the level separation accessible on the progression is called tread. A run of the mill trip with its arrangement and distinctive potential outcomes of tread-riser course of action is appeared in Fig. (a)

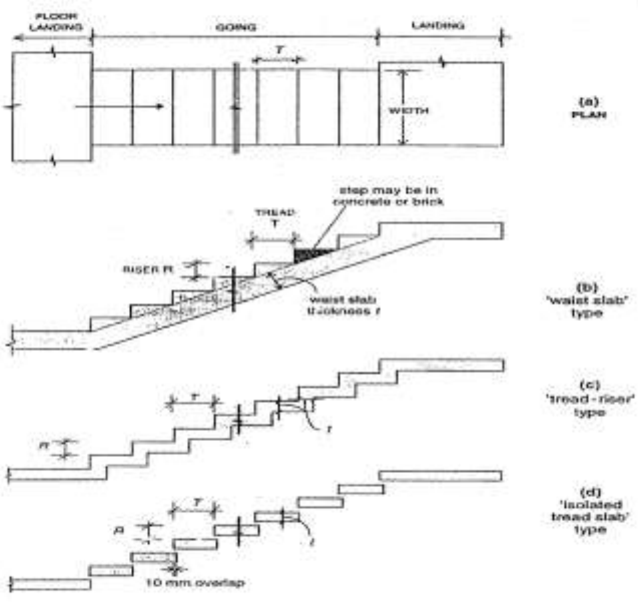


Fig. (a): Schematic View of Staircase

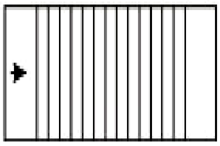
1.2 Classifications of Staircases

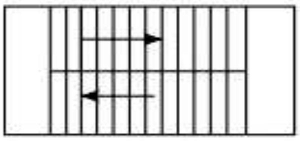
Based upon the compositional contemplations and individual conditions included different courses of action of stair and landing chunk can be made to get distinctive kinds of staircases:

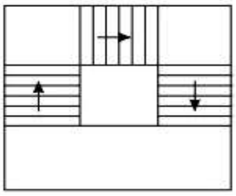
(A). Geometrical Classification

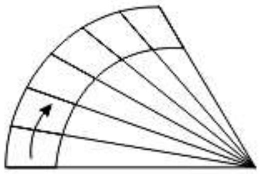
Some of the common types of staircases based on geometrical configurations are depicted in fig. These include:

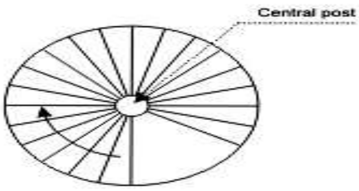
1. Single flight staircase
2. Two flight staircase
3. Open-well staircase
4. Helical staircase
5. Spiral staircase


(a) Single flight


(b) Double flight staircase


(c) Open-well staircase


(d) Helicoidal staircase



(e) Spiral staircase

Fig. (b): Types of staircase

(B) Structural Classification

(a) Stair Slab Spanning Longitudinally:

In stair chunks spreading over longitudinally, at least one backings are given parallel to the riser to the stair piece bowing longitudinally.
1. Bolstered on edges AE and DH
2. Clipped along edges AE and DH
3. Bolstered on edges BF and CG
4. Bolstered on edges AE, CG (or BF) and DH
5. Bolstered on edges AE, BF, CG and DH

(b) Stair Slab Spanning Transversely:

The accompanying are the distinctive game plans:
1. Piece bolstered between two stringer pillars or dividers
2. Cantilever chunks from a spandrel shaft or divider
3. Doubly cantilever chunks from a focal shaft

1.3 Load and Effect of Load on Stair Slabs

Generally stair slabs are encountered with gravity load which consist dead loads and live loads.

(a) Dead Loads:
The dead load included of:
- Self-weight of stair slab
- Self-weight of step
- Tread finish

(b) Live Loads

1.4 Objectives of Study

a) To study the behavior of stair case with various support conditions using staad.pro.

b) Learning of analysis and design methodology which can be very useful in the field.

c) To discover the conduct of stair section display hypothetically utilizing limited component strategy for a given arrangement of limit condition.

d) Understanding of design and detailing concept.

2.0 METHODOLOGY

2.1 Plate Element Theory in STAAD. Expert 2006

STAAD. Expert is a broadly useful basic examination and configuration program with applications principally in the building business - business structures, extensions and interstate structures, modern structures, substance plant structures, dams, holding dividers, turbine establishments, courses and other installed structures, and so on. The program comprises of the different offices to empower this undertaking. Plate/shell limited component is one of these offices whose highlights are clarified underneath.

2.2 Plate Element:

The Plate/Shell limited component depends on the crossover component detailing. The component can be 3-noded (triangular) or 4-noded (quadrilateral). In the event that all the four hubs of a quadrilateral component don't lie on one plane, it is prudent to demonstrate them as triangular components. The thickness of the component might be not quite the same as one hub to another.

2.3 Geometrical Modeling Considerations:

The accompanying geometry related demonstrating standards ought to be recalled while utilizing the plate/shell component summon:

1) The program consequently produces an imaginary fifth hub "O" (focus hub) at the component focus.

2) While allocating hubs to a component in the info information, it is basic that the hubs be determined either clockwise or counter clockwise . For better productivity, comparative components ought to be numbered successively

3) Element viewpoint proportion ought not to be extreme. They ought to be of the request of 1:1, and ideally under 4:1.

4) Individual components ought not to be mutilated. Points between two contiguous component sides ought not to be substantially bigger than 90 and never bigger than 180.

2.4 Plate Element Numbering

Amid the age of component firmness grid, the program checks whether the component is same as the past one or not. On the off chance that it is same, redundant computations are not performed. The grouping in which the component firmness network is created is the same as the arrangement in which components are contribution to component frequencies. In this way, to spare some registering time, comparative components ought to be numbered consecutively. Fig. (c) shows cases of proficient and non-productive component numbering.

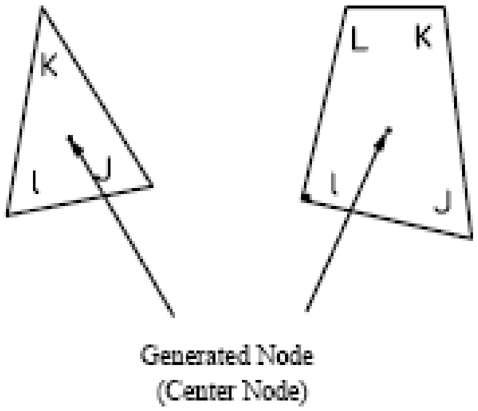


Fig.(c): Generated fictitious node

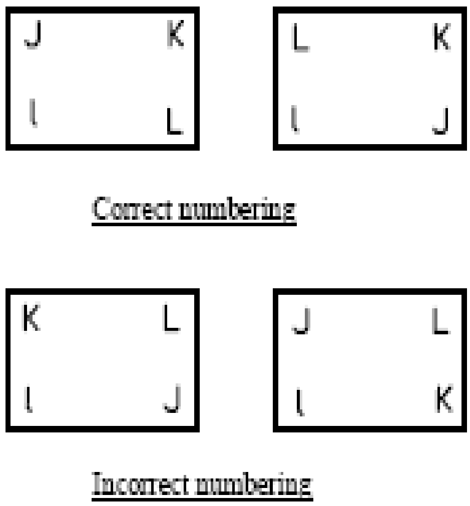


Fig.(d):Numbering of nodes

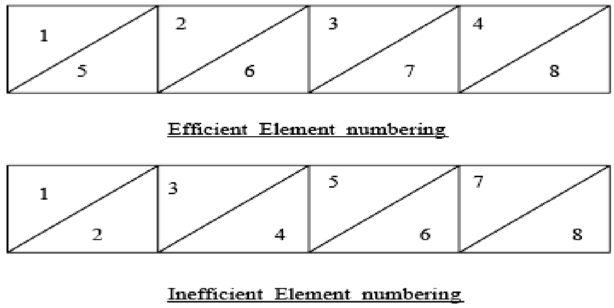


Fig. (e): Way of element numbering

2.5 Finite Element Analysis

Finite Element Method using STAAD.Pro has been used for the analysis of all support conditions. Finite element model of staircase of different SUPPORT TYPES are as shown below:

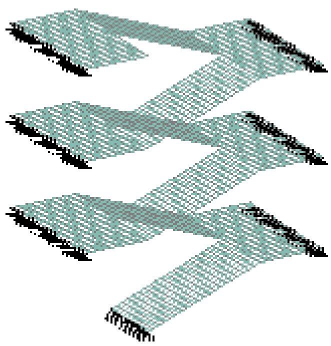


Fig. 4.3: SUPPORT TYPE-1

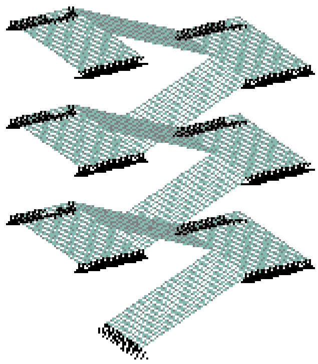


Fig. 4.4: SUPPORT TYPE-2

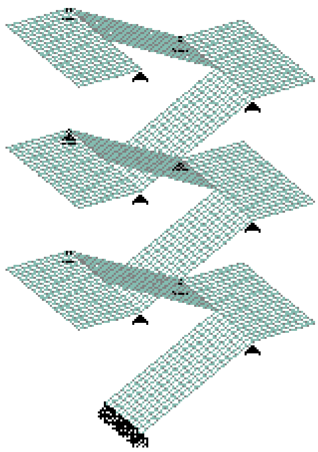


Fig. 4.5: SUPPORT TYPE-3

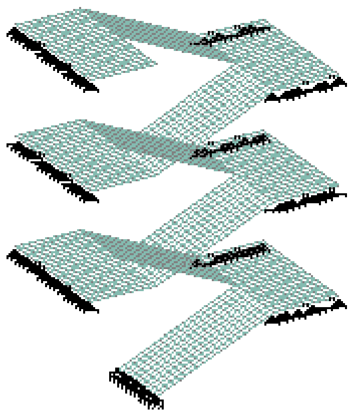
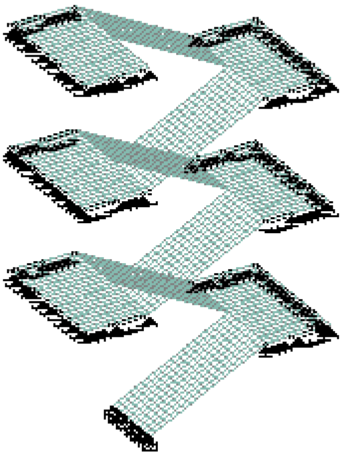


Fig. 4.6: SUPPORT TYPE-4



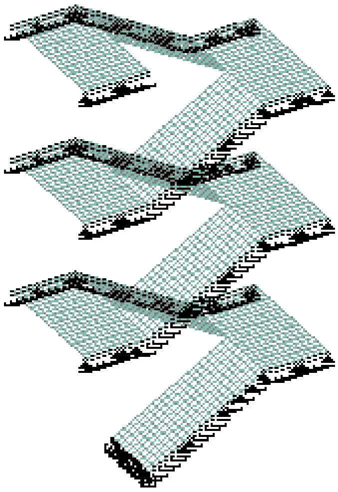


Fig. 4.7: SUPPORT TYPE-5 **Fig. 4.8:** SUPPORT TYPE-6

3.0 COMPARISON OF RESULTS AND PROPOSED DESIGN CONSIDERATIONS

This part manages the near examination among various help conditions, to see the impact of help conditions. For accommodation, the aftereffects of bowing minutes and vertical avoidance are thought about for Landing and Flight width of 1.5m (CASE II) and 2.5m (CASE IV) as it were. Impact of landing width (1.0m, 1.5m, 2.0m and 2.5m) on various help conditions has likewise been talked about in later segment.. In light of the similar investigation of results some helpful plan contemplations have been proposed toward the finish of this part and conclusions in the following section.

Conduct of twofold flight stairs for different supporting courses of action has been examined utilizing the limited component procedure. Plate components were utilized as a part of model. Flexural practices of stair pieces where flights are ceaseless with the arrival are talked about here. The bowing minute (Mx) along the length ofthe trip for stair pieces of commonplace measurements as appeared in are introduced in Fig. 5.2. Twisting minutes along the distinctive segments of a trip of canine legged stairare appeared.

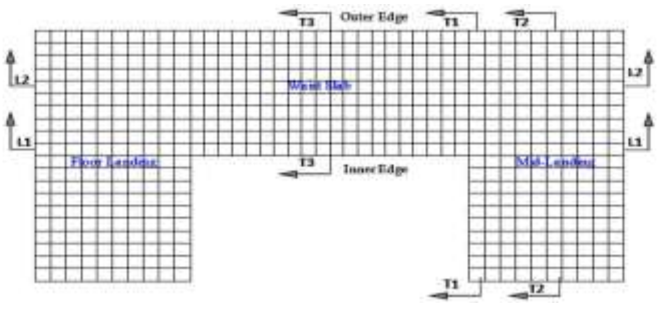


Fig.3.1: Finite Element Mesh of stair slab

Bending Moment M_y is unimportantly little in the slanted segment of the stair section. However, at getting, this minute is of significant extent, particularly in a strip near the kink, which is where the slanted abdomen section and the arrival piece meet. The variety of M_y at various areas of landing are appeared in Fig. 5.4 for canine legged stair.

Bolster write 1 speaks to rather optimistic supporting courses of action and is proposed to give a premise to correlation of the execution of the supporting game plans spoke to by help composes 2 to 6. The flexural practices for types 2 to 6 are fundamentally the same as in dispersion yet not in extent. Two basic areas for the flexural plan of such stairs are watched: (1) The mid traverse area for listing minute; and (2) the wrinkle area, where the arrival piece meets the slanted midsection chunk, for hoarding minute. The practices of SUPPORT TYPE 1 intently looks like that of just upheld shaft. This suggests the stair section does not require any uncommon treatment in view of its collapsed nature. From examination, we find that stair pieces being bolstered on arrivals as in SUPPORT TYPE 2, 5, and 6, running at right point to the bearing of the flight, get huge limiting impact from such supporting game plans.

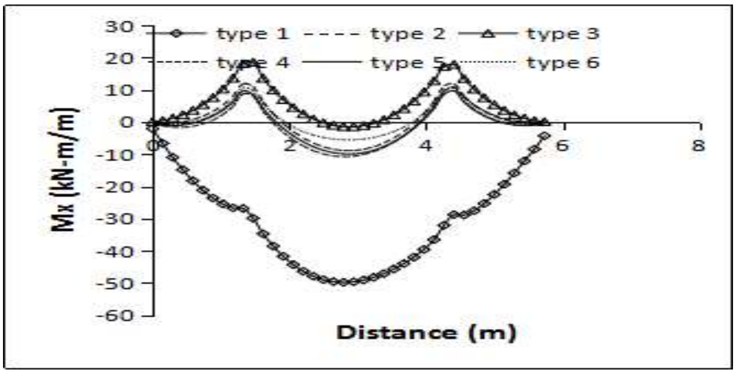


Fig.3.2: Bending Moment Mx at section L1-L1 for stair slabs (landing width 1.5m) of different support conditions

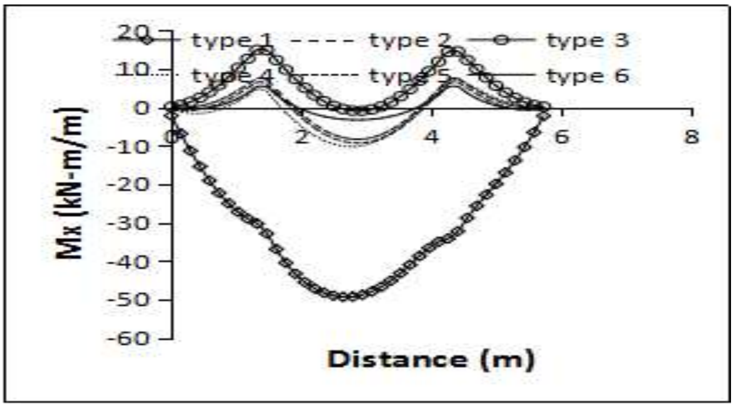


Fig.3.3: Bending Moment Mx at section L2-L2 for stair slabs (landing width 1.5m) of different support conditions

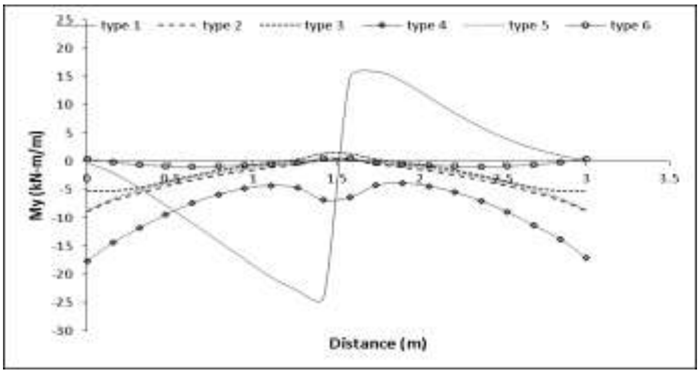


Fig. 3.4: Bending Moment My at section T1-T1 for stair slabs of different (landing width 1.5m) support conditions [refer Fig. 3.1]

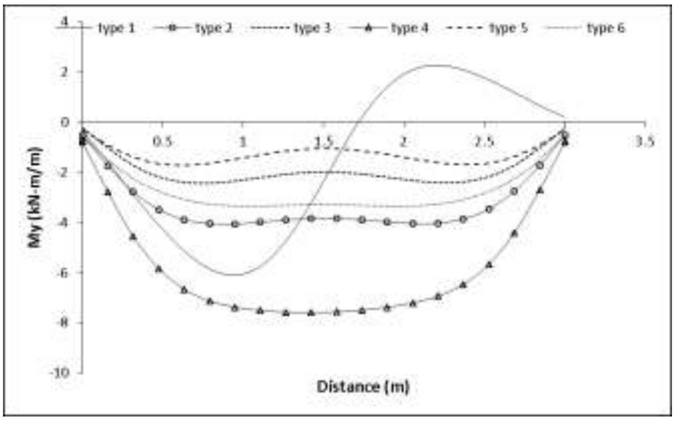


Fig. 3.5: Bending Moment My at section T2-T2 for stair slabs (landing width 1.5m) of different support conditions [refer Fig. 5.1]

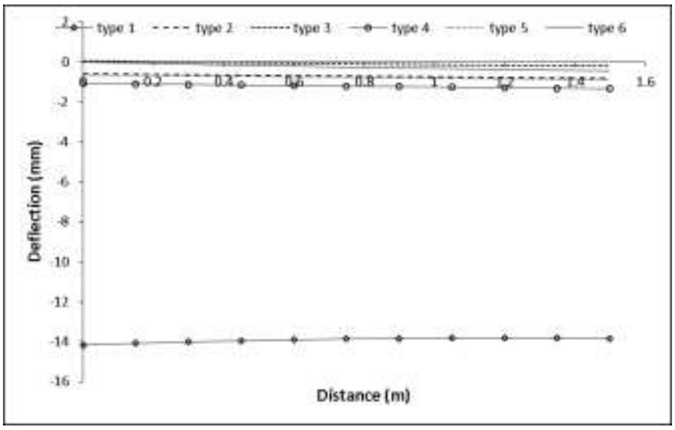


Fig. 3.6: Vertical Deflection at section T3-T3 for stair slabs (landing width 1.5m) of different support conditions [refer Fig. 5.1]

Table-1:Comparison of Critical Moments (sagging and hogging) and Maximum Deflection among all SUPPORT TYPES

Support Type	Landing Width (m)	Mx (Sagging) (kN-m/m)	Mx (Hogging) (kN-m/m)	My (Sagging) (kN-m/m)	My (Hogging) (kN-m/m)	Vertical Deflection (mm)
1	1.5	-57.574	---	-24.103	15.828	-14.177
2	1.5	-8.878	11.918	-8.881	0.261	-0.814
3	1.5	-1.461	20.583	-5.335	1.516	-2.250
4	1.5	-10.799	17.127	-17.670	5.321	-1.342
5	1.5	-9.897	12.698	-8.753	0.289	-0.886
6	1.5	-5.521	10.688	-5.104	0.519	-0.453

3.1 Comparison of Critical Longitudinal Moment (Sagging) Between Finite Element Analysis and Conventional Analysis:

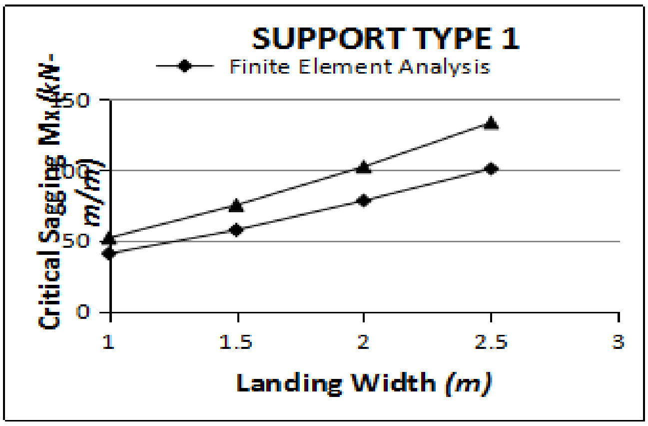


Fig.3.7: Comparison of Critical Longitudinal Moment (sagging) between Finite Element Analysis and Conventional Analysis for SUPPORT TYPE 1

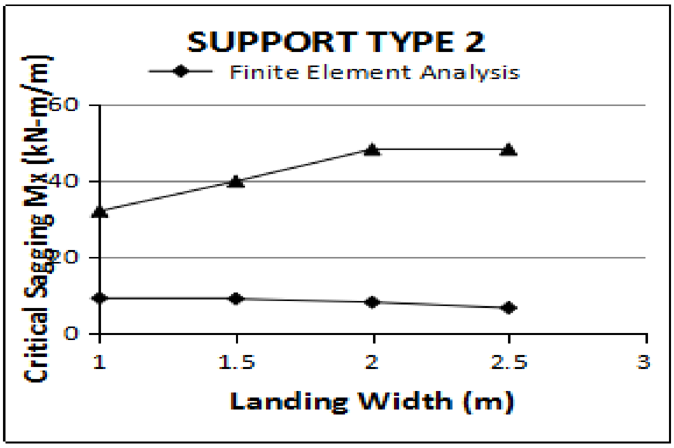


Fig.3.8: Comparison of Critical Longitudinal Moment (sagging) between Finite Element Analysis and Conventional Analysis for SUPPORT TYPE 2

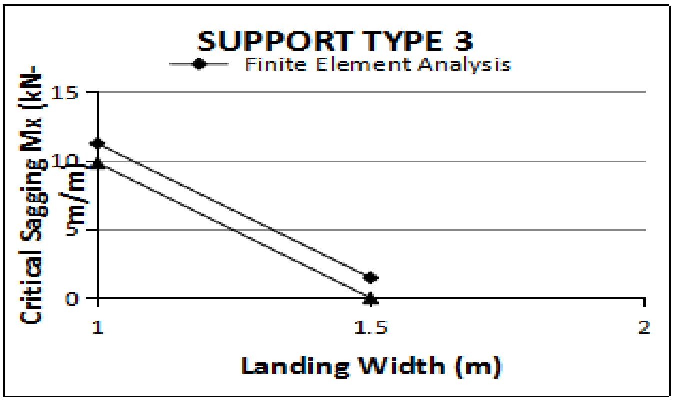


Fig.3.9: Comparison of Critical Longitudinal Moment (sagging) between Finite Element Analysis and Conventional Analysis for SUPPORT TYPE 3

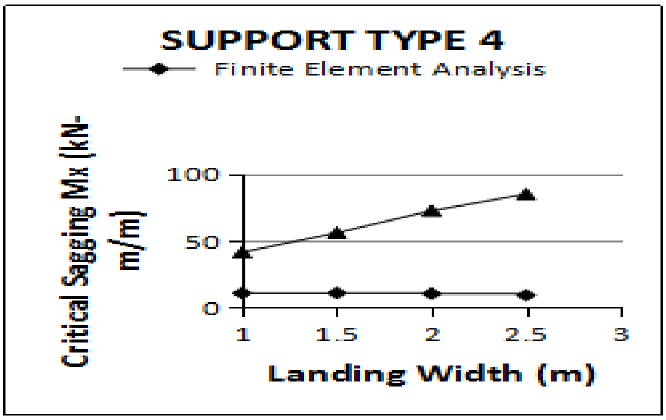


Fig.3.10: Comparison of Critical Longitudinal Moment (sagging) between Finite Element Analysis and Conventional Analysis for SUPPORT TYPE 4

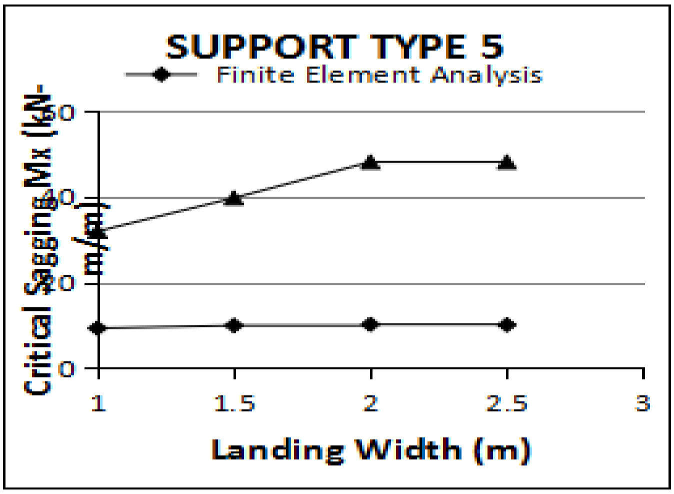


Fig.3.11: Comparison of Critical Longitudinal Moment (sagging) between Finite Element Analysis and Conventional Analysis for SUPPORT TYPE 5

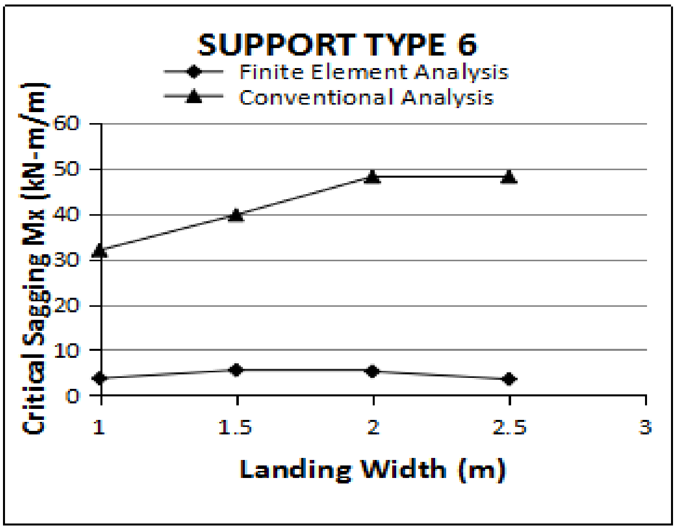


Fig.3.12: Comparison of Critical Longitudinal Moment (sagging) between Finite Element Analysis and Conventional Analysis for SUPPORT TYPE 6

Design Considerations

In light of the expository trial of the stair section with various help condition, the accompanying contemplations might be considered, while outlining stair chunks.

1). If there should be an occurrence of Support Type 1 i.e. Landing section basically upheld at the extraordinary edges, the successful traverse of stair section might be taken as 0.9 times the traverse according to I.S. code i.e. remove between the backings. Notwithstanding the minute longitudinal way, the transverse minute in the region of crimp area might be taken as half of the longitudinal minute.

2). For stair piece Type 2 i.e. Landing section bolstered on the two edges parallel to the bearing of traverse, the listing minute longitudinal way might be computed utilizing range as the 0.80 of even projection of midriff piece. Furthermore, a hoarding minute a similar way, of sum 1.5 times (for up to 2.0m landing width) to 2.0 times (for up to 2.5m landing width) the most extreme drooping minute must be considered close to the wrinkle line (where the midriff chunk meets the upper and lower arrivals).

3). For stair section Type 3 i.e. Landing piece cantilevered, with pillar just upheld at closes [Fig. 4.5], estimation of minute longitudinal way relies on the proportion of landing width and even projection of flight. The minute longitudinal way is generally hoarding with its most extreme incentive close to the wrinkle segment. For a 1.0m wide landing and 2.7m level anticipated length of flight, greatest hoarding minute is observed to be 8.99kNm/m and most extreme drooping is observed to be 11.201kNm/m. For a 1.5m wide landing and 2.7m flat anticipated length of flight, greatest hoarding is observed to be 20.583kNm/m and most extreme drooping is observed to be 1.461kNm/m. For this situation hypothetical minutes (both hanging and hoarding) acquired by Finite Element investigation are observed to be more than the minutes got by the traditional technique by 12 to 15%. In this way additional security must be considered if there should arise an occurrence of cantilevered arrivals.

4). For stair chunk Type 4 i.e. Mid-landing is upheld on the two edges parallel to the heading of traverse and floor landing is just bolstered at the extraordinary edge [Fig. 4.6], the drooping minute longitudinal way might be ascertained utilizing range as the 0.80 of even projection of midriff piece. The minutes are relatively comparative as in the event of Type-2.

5). For stair piece Type 5 i.e. Landing section just bolstered along the three outside edges [Fig. 4.7], the drooping minute longitudinal way might be computed utilizing range as the 0.80 of flat projection of midsection chunk. The hoarding minutes might be increment by 30% when contrasted with listing minute. My drooping and hoarding is relatively same as if there should be an occurrence of Type-2. There is little impact of extra help of arrivals at extraordinary edges.

6). For stair section Type 6 i.e. Landing section and waist piece is essentially upheld at its external edges [Fig. 4.8], the listing minute longitudinal way might be computed utilizing range as the 0.60 of flat projection of abdomen piece. In Type-6 that is supporting the midriff chunk on dividers notwithstanding the arrival bolstered on two inverse edges the longitudinal hanging moment is lessened by 40% and longitudinal hoarding minutes are decreased by 40% as in Type-2. The transverse drooping minute is diminished by 20%, and for landing width 1.5m, Type-2. The vertical redirection likewise decreased to half to land width up to 1.5m however there is no such impact for landing width more than 1.5m..

4.0 CONCLUSIONS

a. Following conclusions can be drawn based on ponder done on conduct of pooch legged stair section with various help conditions.
b. Stair piece does not carry on like a straightforward one way section regardless of whether it is bolstered on outrageous edges as accepted in ordinary technique.
c. Considerable hoarding minutes are produced both in longitudinal and transverse bearing at various areas which are not found by regular technique
d. Following areas in stair piece are basic to the extent flexural stresses are concerned.
e. Mid traverse of flight, for a hanging minute in the longitudinal (x) heading.
f. Kink line and its vicinity,for a hogging moment in the longitudinaldirection
g. Landing slab, a strip adjacent to the kink line of half the width of the landing, for moment in lateral direction (y).

- Landing derives noteworthy restraining effect from supporting structural elements.
- Study reveals that when effect of wall over outer edge of waist slab is taken as hinge support considerable reduction in the moment is noticed.
- Hogging moment also develop in a stair slab, which are not given due attention in various leading codes of practice.
- Different supports arrangements have different distribution of moments.
- Landing span also considerably influences the distribution of bending moment.
- The longitudinal moment and transverse moment obtained from finite element analysis is substantially less than that calculated from conventional analysis.

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