International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Issue-03, June 2022

Design of Reinforcement of Overlapping Shear Keys in Bridges

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Abstract **Bridge is the main transportation media for the water or vehicles or at any place having obstruction from where no one can pass. In that case,there is the necessity of the bridge. Bridges are also of many types but in this study the normal bridge is made up of piers, abutment, slab and foundation. Same components of the bridge are also required for the box girder bridge but instead of piers, wings are used.**

In this research, the stability of the girder by using shear key are analyzed in ANSYS 19.2 software. There are three box girder used that are inter connected with each other with the help of shear key. The examination methodology includes finite element analysis of extension models with reasonable help and loading conditions. The outcomes demonstrate that the box girder have adequate solidarity to oppose breaking from vehicular burdens, yet shrinkage strains cause high tensile stresses in the shear key areas and lead to intelligent breaking. The examinations showed the most noteworthy burdens were frequently close to the backings, rather than at mid span.

The model of the bridge is formed in the ANSYS software and applied the static and dynamic loading. Here HS25 trucking loading are used by using AASTHO code. The deformation of the girder, shear stress, shear strain, normal stress and many more parameter are calculated. Compare all the joint loading with transverse normal stress and strain is calculated.

Keywords —ANSYS, AASTHO code, Shear Key

I. Introduction

Transportation offices across the U.S. have been utilizing substantial box brace bridge since the 1950's. This bridge style represents a critical level of new what's more, existing bridge (FHWA 2005). The segment profundity is one of the most significant contemplations for another bridge, as the upward leeway of an bridge influences many expenses related with bridge development. The concrete box brace bridge is appropriate for interstate designs that require a restricted segment profundity, short to medium ranges, and fast development. The underlying expense of the bridge is high when contrasted with other bridge types, yet, the upsides of box support spans frequently legitimize the greater expense.

The development interaction for a multi-beam bridge happens in particular stages. The first stage is the development of the crate braces off-site, at a precast cement producing office. The advantage of the precast interaction is that the maker would be able keep an elevated degree of value command over the materials utilized in the development of the box brace. The following stage is the on location development of all the bridge sub-parts, like bowed covers and move toward sections. Whenever the site is prepared for the arrangement of the box braces, they are lifted into place with a crane. Regularly, the crate braces lay on bearing cushions that will oblige the warm lengthening experienced by the crate braces. The last period of the development cycle is the production of joints, called shear keys, that interface the singular box supports together and move vehicle loads from one beam to the following so they share the loads delivered by vehicular traffic. What's more, a composite deck piece might be applied either as an essential piece of the shear key projecting.

The shear key gets its name from the exchange of vertical shear powers between nearby braces. It has a math that makes the two braces avoid as a solitary unit. At the point

 DOI : 10.35291/2454-9150.2022.0318

when present, a composite deck chunk additionally adds to the exchange of powers between nearby boxes. The multi-bar bridge cross area displayed in Figure 1 is a Texas Division of Transportaion (TxDOT) standard and uses a huge shear key.

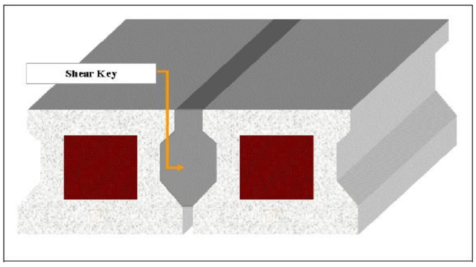

Fig-1: **Schematic of Two Box Girders and a Shear Key**

II. LITERATURE REVIEW

Dinesh H , Sowjanya G V, S R Ramesh, dr. T V Mallesh Aug 2019

A Skew span is an extension that assembled diagonally from one bank to another. An endeavor has been made to comprehend the conduct of the slant spans with various slant points also, FEM procedures. This paper incorporates various methods also, related works that have been accomplished for various slant point on spans by utilizing CSi span programming. The different load rules on spans were considered according to Indian Road Congress and its revisions. The conduct of the slant spans with the diverse length, slant points are for the most part between related. The adjustment of the various elements of the extension can influence the different boundaries like twisting second, shear power and torsional impacts. This segment sums up the finish of this review on impact of slant on the conduct of brace span investigation. For the most part, the benefit of bowing diminishes with expansion in the slant point, the worth of shear power and Torsion increments with expansion in slant point. For the mix of dead burden and live burden, it was noticed that, bowing second, second because of twist, and same configuration bowing second was expanded slowly with increment of slant point from 0° to 60°. It has been seen that for all span models considered in this review, the longitudinal Uprooting is 0.13 m most extreme for 60˚ slant.

Underlying reactions for dead burden twisting second reductions at the left outside brace and increments at right outside support. The dead burden shear power will be most extreme at left outside support and dead burden twist will be greatest at right outside brace. The examination on slant span is finished by differing their projection slant point, section level and length plan. The little change in the construction mirror the huge changes in the result. The slant in the scaffold makes the examination and plan confounded and tedious. The way of behaving of extension in each slant point is fluctuates and increment in slant point increment the difficulty in plan. Scientific and mathematical investigations of slant span with enormous slant point have exhibit that the static and dynamic reactions of these extensions are unique from those of their straight partners. **Junyi Meng et.al.**

Different exploratory and insightful test is done on the slant extension to comprehend the reaction of scaffold in various condition. The grillage and limited component technique is use to investigate the construction. **Khaled M et.al.**

Both the technique component technique the section is discretized in are unique in relation to one another and not comparative for each lattice size, in grillage examination the piece is discretized in matrix of interconnecting shaft also, in limited matrix of interconnecting plate. In the Comparison of both the strategy, grillage technique is not difficult to utilize and not consuming additional time as contrast with the FEM and limited component strategy required more exertion and time in demonstrating than grillage, and give the exact outcome.

There are different kinds of powers are following up on the spans like breeze, seismic, dead, live loads and so forth these powers produce different response as contrast with the typical scaffold since in ordinary scaffold load response and dissemination is uniform and in slant span the calculation of the scaffolds isn't straight so the circulation of powers isn't uniform, non-uniformity in force circulation it impacted the security of the span. The powers following up on the extension is following up on a specific point, it influence the solidness of the extension and the most extreme response is acting at the insensitive corner and lesser on opposite end. **Arindam Dhar et.al .**

Fan Feng, Fanglin Huang, 19 August 2021

Another sort of substantial board with a shear key is proposed, also, examples of this sort of scaffold board are created. i.e. shear limit of the wet joint of the examples is contemplated through exploratory, hypothetical, and mathematical examination. i.e mechanical properties of the examples are talked about by dissecting extreme shear pressure, the dislodging of the wet joint, the shear strain of the wet joint, and the strain of the support recipes of the shear strength are inferred, and the limited component models of the examples are considered for expectation. Primary ends of this paper are as per the following:

(1) In request to test a definitive shear limit of the wet joint, the test stacking mode is planned. Unpleasant the test, under similar material qualities, a definitive shear limit of the new wet joint construction is 73% higher than the traditional one.

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(2) The disappointment cycles of three sorts of examples are examined. The disappointment of Type 1 is shown, and the shear resist the wet joint is extremely enormous. The disappointment of Type 2 is primarily brought about by interfacial debonding. The interfacial debonding of Type 2 happens from base to top along the substantial interface. The interfacial debonding of Type 3 happens along the concrete-substantial interface. For Type 3, the shear key disappointment initially happens and afterward the interface debonds.

(3) The equations of a definitive shear limit of three examples are determined, and the anticipated outcomes are in adequate concurrence with the exploratory outcomes.

Bhupendra Solanki, Megha Thomas (APRIL 2018)

Objective of the review is to comprehend the effect of range length on slant span. A review would be made for differing range length. Slant point is 0, 10, 20, 30, 40, 50 and 60 separately. Slanted scaffolds are broadly use to keep the arrangement straight, with one conspicuous application being for high velocity railroads and thruways. The extension setup for example ranges and especially width would be considered according to IRC-6. A correlation would be made between the outcomes for diverse slant spans for various range length. An endeavor would be made to plan a condition however which slant impact on plan could be determined. This parametric review would be performed by limited component demonstrating of extensions in Csi Bridge Software.

The increment the slant point diminishes the twisting minutes. Slant point likewise influence the shear power and twist. Stress stream in the deck of the scaffold shows that the with increments slant point more pressure are at the inhumane corner of the deck and less at intense corner as contrast with the harsh corner. This may expands the odds of the upsetting so we need to give additional thickness of the deck or support to make the insensitive corner more grounded to oppose more pressure.

Benjamin Raison R; Freeda Christy C (April-2016)

The underlying conduct of precast cement segmental scaffolds generally relies upon the conduct of the joints between fragments. The current act of precast cement segmental spans is to utilize little keys that are typically unreinforced, regularly dry, and disseminated over the tallness of the web and the rib of substantial portions. In any case, requires the presence of segmental joints to move the heaps between adjoining portions, which focuses on the significance of getting primary security and functionality. Subsequently, need is for research on the conduct of the segmental joint for the constructions raised by the precast segmental development technique. The work in this paper manages the shear slip of the shear keys utilized in prestressed concrete segmental scaffolds because of the outside load for which it is dissected utilizing Limited component investigation and exploratory works and the end is given dependent on different results contemplations.

The break design acquired mathematically uncovered that the break, which is called S break, first shaped at the base corner of the key of the male piece of a joint at around 72–80% of a definitive shear strength and proliferated sideways and up from the base key at just about 45 , which is incidental with exploratory perceptions.

III. METHODOLOGY

Box Girder Description

The box section, shear key, and slab are modelled using three dimensional finite element model. The box girder dimension is 40m x 40m x 7m and their slab dimension is 40m x 40m. the shear key is provided in between the two girder provided the groove in between the girder. In this model there are three boxes girder are used and two shear keys are provided. The first and last end are applied by fixed support. The whole model are formed in ANSYS 19.2 software where there is firstly formed the geometry of the model and then provided the dimension of the model. The model of the composite box girder is as follows.

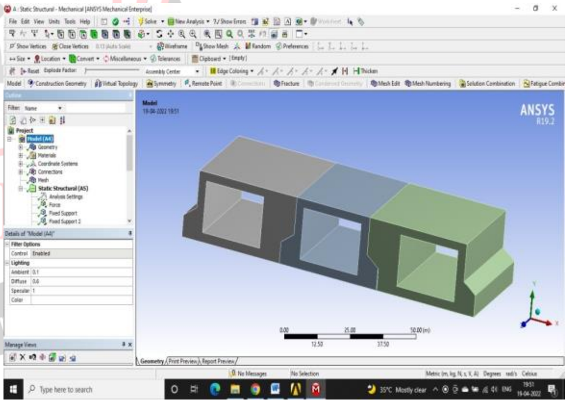

Fig-2

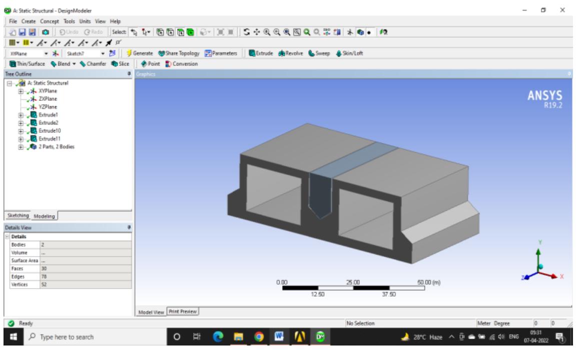

Fig-3

Fig-2-3: Model of box Girder Bridge and shear key provided in between two girders

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Methodology adopted for Box Girder

Open the ANSYS workbench and drag the analysis system to create the standalone system in the workbench. After that name the file name and save it into the computer.

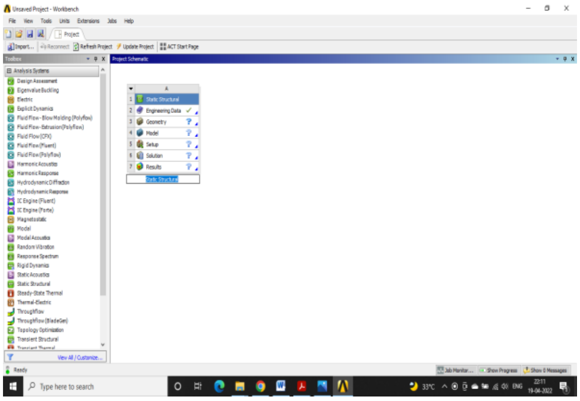

Fig-4: Static Structural analysis System workbench

Set the engineering source data by double clicking on engineering data command. In that tab the material and their properties are shown. In this the material properties are selected for the project which is used in the structure.

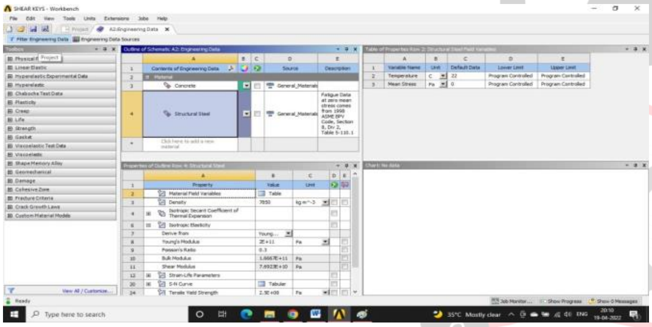

Fig-5: Engineering Data Source

Now go to the geometry tab by right click and choose DIM programming for the framework analysis. For 3d analysis another tab are used. Then after the modelling are started. The units are set out before the modelling of the structure.

The geometry command is like as a AUTOCAD software command but the difference is that in AUTOCAD the drawing is formed with proper dimension and in ANSYS, first of all the structure is made and then the dimension is set out.

Modify all the structure and set the shear key in between the two girder. Make a solid girder and then create a hole in the solid girder. As the modelling of the girder is done then close that window and open the model window for further analysis.

In model window the meshing on the structure is generated with follow the proper procedure and the meshing to be generated that is shown below.

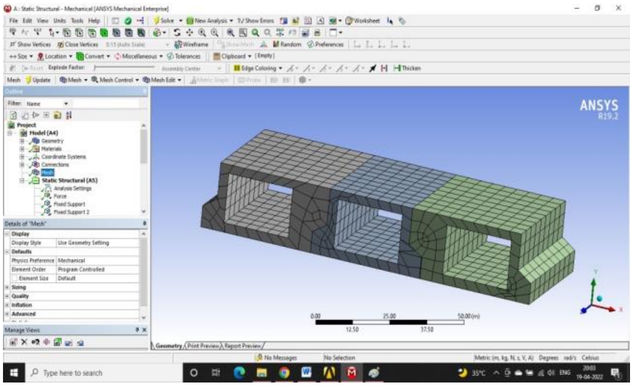

Fig-6: Meshing on the structure

Apply the support, force and pressure to the structure which is shown below.

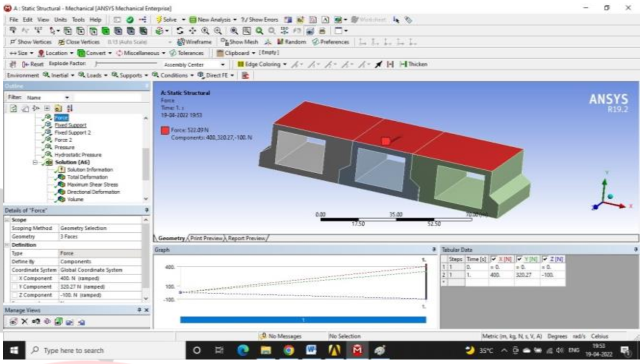

Fig-7: Force applied to the structure

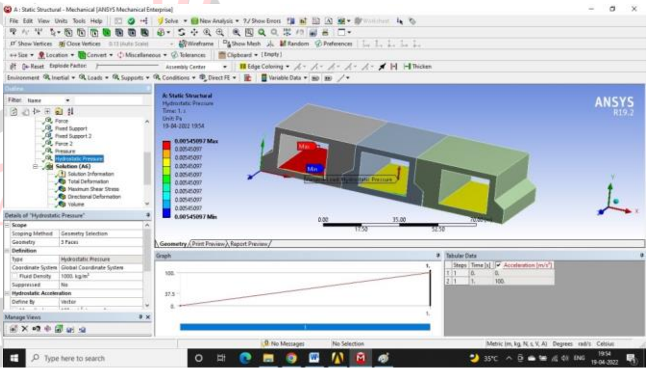

Fig-8: Hydrostatic pressure applied on the girder

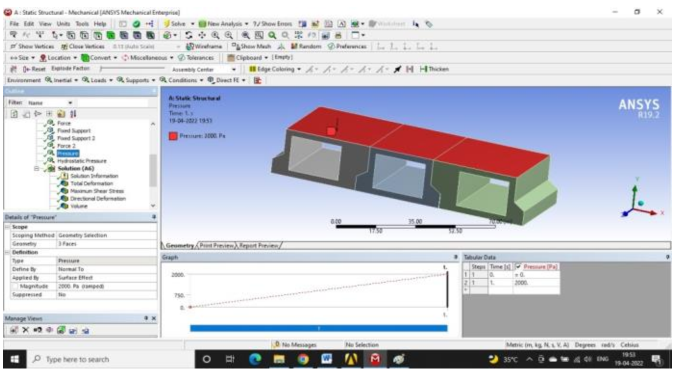

Fig-9: Pressure applied on the structure

The HS25 Loading on the bridge is considering so that the pressure applied on the bridge is about 2000Pa on the slab region.

 DOI : 10.35291/2454-9150.2022.0318

ISSN : 2454-9150 Vol-08, Issue-03, June 2022

IV. RESULT AND DISCUSSION

Total Deformation

Total deformation is the option that is used for checking out the deformation in X, Y and Z co-ordinates. In this analysis the result is calculated for the bridge girder is shown below.

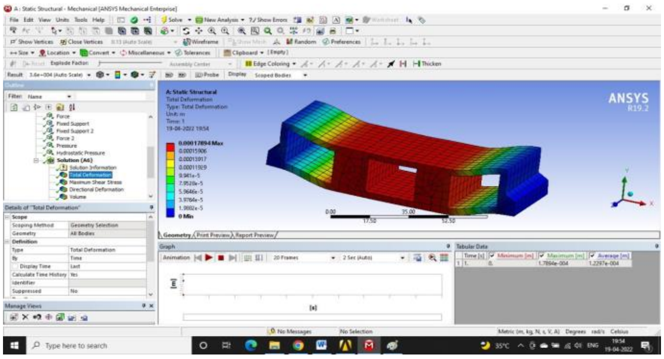

Fig-10 Total deformation of the bridge girder due to 2000Pa Pressure

Time	Minimum (m)	Maximum (m)	Average (m)
1	0	1.7894 E-004	1.2297E-004

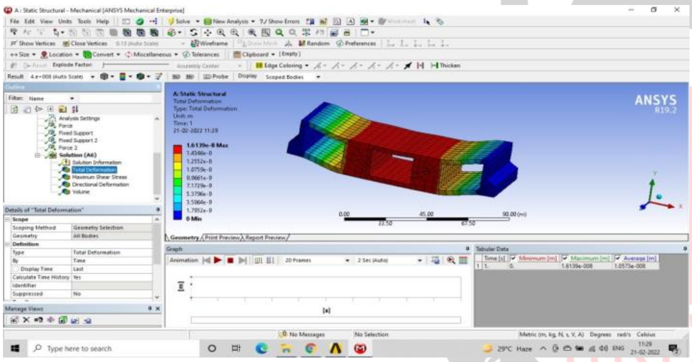

Fig-11: Total deformation of the bridge girder due to 25 Pa Pressure

Time	Minimum (m)	Maximum (m)	Average (m)
1	0	1.6139E-008	1.0573E-008

In this the total deformation for 2000Pa loading on the bridge girder has a minimum deformation of 0 m and the maximum deformation is 1.7894 E-004. And the average deformation is 1.2297E-004 m is very negligible but in case of 25Pa, it is 1.6139E-008 m maximum deformation and the average deformation is 1.0573E-008 m. from this it is concluded that as the loading increases the deformation of the bridge girder increases.

The failure effect in the shear key occurs due to gradually up gradation of truck loading. The reinforcement provided in the slab region to be bending due to the loading. Reinforcement is provided for the purpose of absorbing the tensile force generated by the loading condition which results the deformation in the structure occur.

Directional Deformation

The directional deformation is the deformation that is produced due to the x co-ordinates, Y co-ordinates and Z co-ordinates. In this analysis the directional deformation is caused due to the loading condition and their values are shown below.

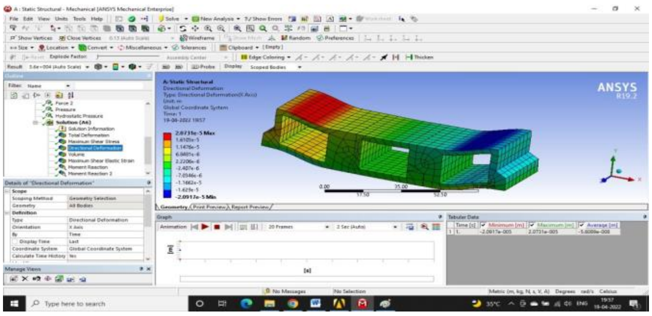

Fig-12 (a)

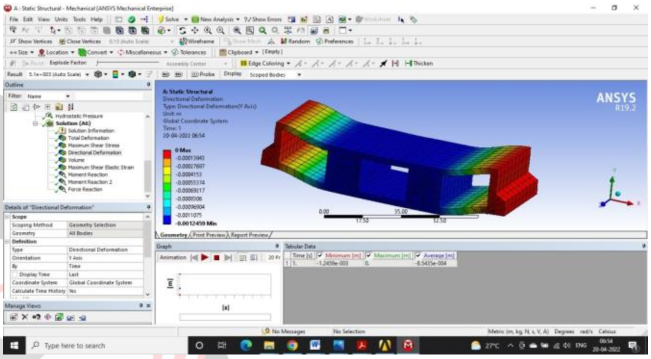

Fig-12 (b)

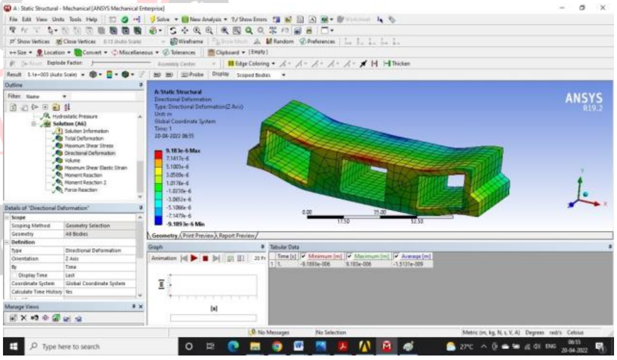

Fig-12 (c)

Directional Deformations in Fig-12 (a) X-axis, Fig-12 (b) Y-axis,Fig-12 (c) Z-axis

Directional Deformation				
Time	Axis	Minimum (m)	Maximum (m)	Average (m)
1	X	-2.0917E-005	2.0731E-005	-5.6089E-008
1	Y	-1.2459E-003	0	-8.5435E-004
1	Z	-9.1893E-006	9.183E-006	-1.5131E-009

In this analysis it is concluded that the directional deformation is made maximum in Y direction as compare to X and Z Axis. The average value for the deformation in

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ISSN : 2454-9150 Vol-08, Issue-03, June 2022

x direction is -5.6089E-008 m, in Y direction is -8.5435E-004 and in Z direction is -1.5131E-009. It is clear that the deformation occur in Y direction is more so that it is needed to sort out the deformation problem.

Maximum Shear Stress

The maximum shear stress theory states that the breakdown of material depends only on the maximum shear stress attained in an element. It assumes that yielding starts in planes of maximum shear stress. The maximum shear stress occur in the bridge girder is shown in the figure.

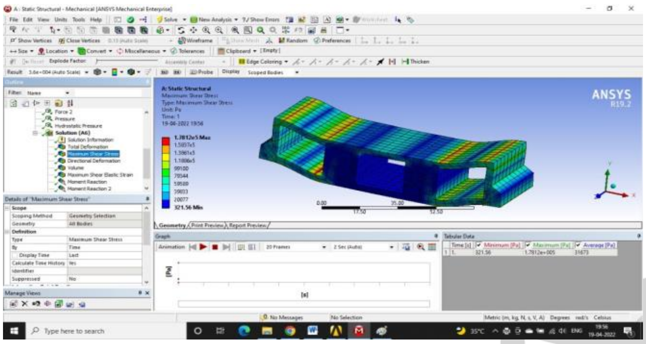

Fig-13: Maximum shear stress in the bridge girder

Maximum Shear Stress				
Time	Axis	Minimum (Pa)	Maximum (Pa)	Average (Pa)
1	X	321.56	1.7812E+005	31673

In this result the minimum shear stress is produced in the bridge girder is 321.56Pa and the maximum shear stress is produced in the bridge girder is 1.7812E005 which is maximum. According to the theory, the yielding starts in the bridge girder due to the loading applied.

4.8 Transverse Moment

Transverse moment was analyzed for accommodation. For bridge models with strong components in the section, the Transverse moment was determined utilizing the braid values given at each nodal area and a snapshot of dormancy in light of slab thickness.

Figure 28 shows the Transverse moment in the shear key from one finish of the extension model to the next. This is the Transverse moment coming about because of the utilization of the 2000 Pa point load applied over the centroid of one of the columns as examined before. This information doesn't show the outcomes for the extension model fabricated totally from shell components, which will be talked about later.

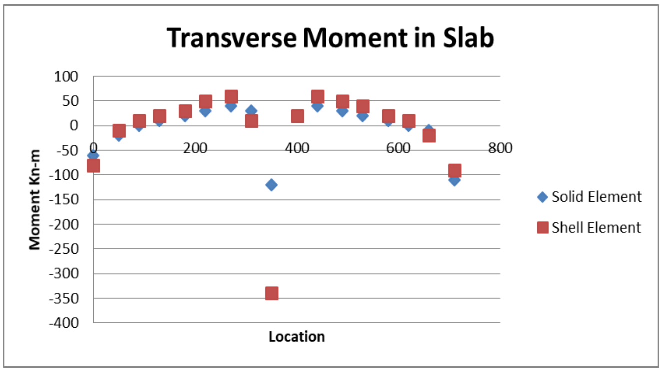

Fig-14:

(Above graph shows Transverse Moment in slab)

Location	Transverse Moment	
	Solid Element	Shell Element
0	-60	-80
50	-20	-10
90	0	10
130	10	20
180	20	30
220	30	50
270	40	60
310	30	10
350	-120	-340
400	20	20
440	40	60
490	30	50
530	20	40
580	10	20
620	0	10
660	-10	-20
710	-110	-90

In this graph it is shows that the solid element and the shell element of the slab component are produced and their moment at various location are also shown in this graph. The bending moment of shear key and their slab are quite same when it observed.

One thing to note is the moment close to the finishes for the Solid Model with Coarse Mesh versus the wide range of various bridges. This was the main model without end diaphragm in the container support. Whenever end diaphragm were available, the Transverse moment was lower on the grounds that the brace didn't insight as much misshaping close to the help areas thus less turn was forced on the slab. In this way, the presence of inward diaphragm was a significant component in the way of behaving of the extensions and was remembered for each model as talked about in the part with respect to Solid Model Description.

4.9 Transverse Normal Stress Profile

The aftereffects of interest in this review are the ordinary and shear stresses in the shear key and composite bridge. It is realized that breaking of the shear key happens along an upward plane, so the stresses that are liable for this are

 DOI : 10.35291/2454-9150.2022.0318

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Issue-03, June 2022

probably going to act opposite to this plane. So to observe this data, a PC routine was composed to report the stresses however the profundity of each shear key, from the highest point of the composite section to the lower part of the keyway. A profile was then worked along an upward line at the focal point of the shear key as displayed in Figure .

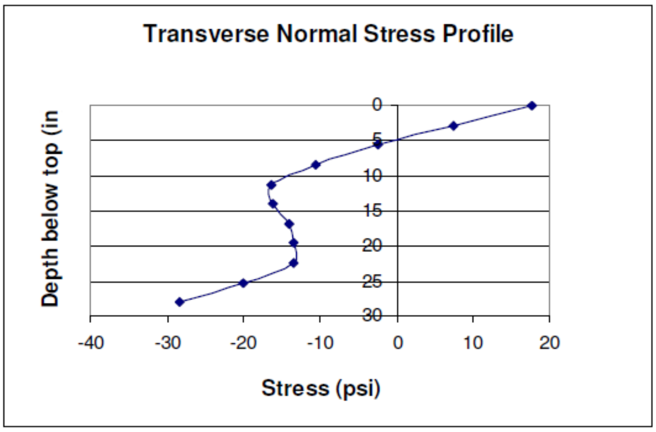

Fig-15: (Above graph shows Transverse Normal Stress Profile)

The resulting stress profile, showing transverse normal stress from the peak surface to the bottom of the keyway is shown in Figure 4.10. This represents the stress at a single location on the bridge, and was taken from a bridge model with a concentrated load. The stresses represent the transverse normal stress at different depths along the vertical line of the cross section. The centreline of the shear key was chosen to represent data for the entire shear key. Transverse normal stresses in the middle of the shear key and those existing on the either side at the beam-shear key interfaces were essentially the same in every case.

4.10 Shrinkage in the Slab

The maximum transverse normal stress in the shear key or composite slab due to slab shrinkage is shown in Figure 4.11. In this case, the full model shows a fairly consistent value around 750 Pa near midbridge. The sub model shows a value near 900 Pa. The results indicate that the full bridge model underestimates maximum transverse normal stresses by about 20%.

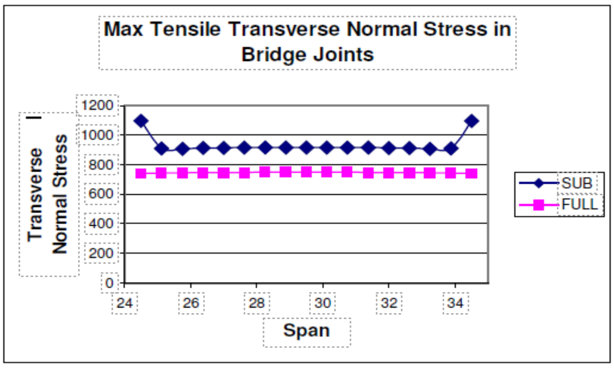

Fig-16:

(Above graph shows Maximum Transverse Stress in Sub model due to Slab Shrinkage)

There are additionally peaks in pressure close to the edges of the sub model. These are a consequence of applied limitations which are interjected from the worldwide model and prompt the pressure to spike around here accordingly. These spikes in pressure close the sub model cut limits are common of the information introduced in this part. Since they are made up and just a consequence of the displaying procedure, they will be ignored.

The stresses through the profundity of the shear key and composite slab are displayed in Figure 4.12. The outcomes here demonstrate that the stresses follow a similar example, however that the sub model shows a more extensive variety in stresses in the upper piece of the shear key and lower part of the composite section. The full extension model does exclude this cooperation between the section and shear key in light of the fact that the components are bigger and the impacts get arrived at the midpoint of out.

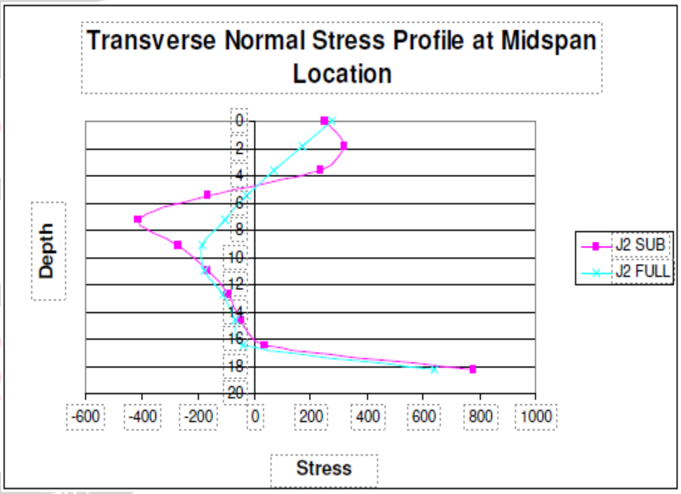

Fig-17:

(Above graph shows Stress Profile for Slab Shrinkage)

Generally, the pressure profile and maximum stresses analyse well between each model when slab shrinkage is thought of. The outcomes given by the full model ought to give sufficient precision to use in the examination of the shear key.

4.11 Shrinkage in the Shear Key

The greatest cross over typical pressure in the shear key or composite section because of shrinkage in the shear key is displayed in Figure 4.13. The full extension model shows a most extreme ordinary pressure almost 700 Pa though the sub model gives a consequence of around 450 Pa. The full bridge model seems to misjudge most extreme pliable stresses by around half.

 DOI : 10.35291/2454-9150.2022.0318

ISSN : 2454-9150 Vol-08, Issue-03, June 2022

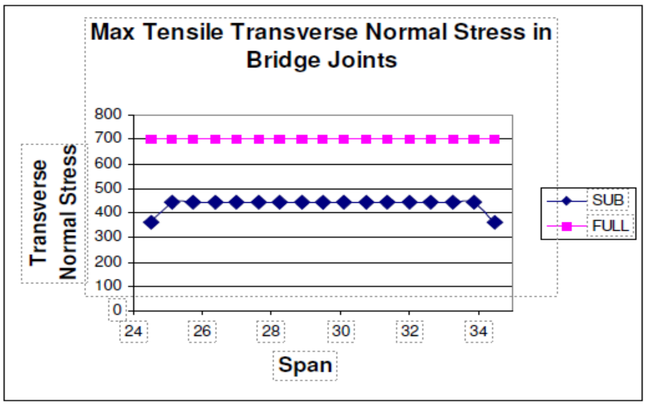

Fig-18:

(Above graph shows Maximum Transverse Stress in Sub model due to Shear Key Shrinkage)

The stresses through the profundity of the part are displayed in Figure 4.14. For this situation, the sub model shows that the stresses change close to the highest point of the segment among pressure and strain, and the region of the shear key close to the top is under a lot of malleable pressure. The full extension model doesn't show strain around here, so there is some worry that the full model does exclude this impact. The stresses close to the lower part of the shear key have a similar example, however the sub model shows more pressure and a less strain than the full extension model.

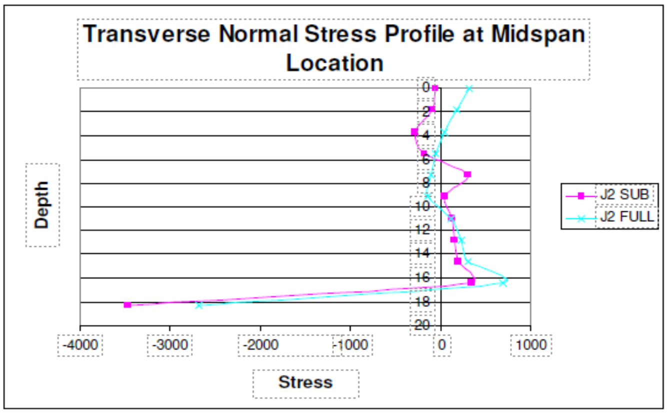

Fig-19:

(Above graph shows Stress Profile for Shear Key Shrinkage)

The distinctions between the two models under shear key shrinkage loads are very enormous. The full bridge model makes a terrible display of addressing the most awful tractable loads and shows the opposite pressure conditions from the sub model at the highest point of the part. The explanation that this happens is presumably because of the size of the components utilized in the shear key. The components making up the shear key are the places where stresses are applied and they are additionally the places where stresses are being estimated, and this can present blunders.

V. CONCLUSION

1. The average total deformation due to 2000Pa pressure on the bridge is 1.2297E-004 which is very greater as compare to the deformation of the bridge having pressure 25Pa. from this it is concluded that as the pressure increases the deformation increases.
2. In Y axis the directional deformation has a greater value as compare to the X and Z direction. In Z direction the more precaution to be needed while designing the bridge with shear key.
3. The average shear stress is produced in the bridge girder is 31673Pa. due to which the yielding is getting started in the bridge girder.
4. In this result, the above value shows that the strain produced in the bridge girder is negligible i.e. 4.1175E-007 m/m. it is very much negligible value according to the structure.
5. The force reaction is calculated in X, Y and Z direction are calculated and the total reaction is found to be 7.0212E+006 N. The fixed support is provided in the first corner and the last corner of the bridge girder due to which the force reaction in X, Y and Z direction are calculated. In this the maximum force reaction is calculated in X direction.

VI. FUTURE SCOPE

1. The design of the full length shear key is provided in bridge girder and analyses in the software.
2. The span of the bridges will be increased so that at least 20 trucking loading is applied to the model.
3. Comparative analysis of the normal bridge and the shear key applied bridge will be calculated.

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