ANALYSIS AND DESIGN OF FIBER REINFORCED POLYMER EXTERNALLY PLATED TO REINFORCED CONCRETE STRUCTURES

SK SWATHI
Department of Civil Engineering
ASHOKA Institute of Engineering & Technology
Malkapur (V).Choutuppal (M). Nalgonda Dist-508252
swathicivil79@gmail.com

R.NARESH Asst. Prof.
Department of Civil Engineering
ASHOKA Institute of Engineering & Technology
Malkapur (V).Choutuppal (M). Nalgonda Dist-508252

ABSTRACT:

Fortifying strengthened cement (RC) shafts by holding steel or fiber fortified Polymer (FRP) on its strain confront has turned into a mainstream retrofit strategy because of its quick, basic and different favorable circumstances. The debonding along the Steel-Reinforced solid bar blend can cause to disappointment of the structures. Safe outline of such a quality to the RC bar requests a genuine and intimative debonding quality model. The interfacial burdens go about as an essential part in carryout this sort of debonding disappointment of repaired structures. This venture displays a cautious limited component examination concerning interfacial worries in the cement layers holding RC pillar and soffit plate. Limited component demonstrating issues like legitimate choice of contact amongst disciples and symmetry conditions are first talked about, with specific consideration on suitable limited component networks for the exact assurance of interfacial burdens. The interfacial burdens are connected at plate end has been dissected for two instances of stacking taken, one is by applying consistently dispersed load and the other one is a two point stacking. Two extraordinary cases are considered in two point stacking for the situation when the plate ends with-in the steady minute locale (CMR) and for the situation when plate is reached out past consistent minute area where twisting minute is negligible. Use of these worries in the glue layer close to the plate end clarified the noteworthiness in considering their impact in flexural debonding

INTRODUCTION:

Fortified solid structures are by and large enhance their components time to time . The principle contributing components are change in their utilization, new outline guidelines, absence of upkeep rehearses, crumbling because of consumption caused by presentation to a forceful situation and mishap occasions, for example, tremors.

In such kind of conditions, there are two down to earth arrangements: substitution or retrofitting. Full structure substitution may have determinate hindrances, for example, sparing for material and labour. This substitution process gives a domain contamination and contact is burden to the encompassing circumstances .e.g. activity issues. If there should be an occurrence of any shot or relying upon structure conditions go for better to repair or update the structure by retrofitting.

The fortifying of strengthened solid pillars by holding a soffit plate holding with fortified solid structures has turned into a well known retrofit strategy. This soffit plate holding technique has a few favorable circumstances, for example, expanding the unbending nature and quality of a current flexural individual from a structure with insignificant effect on the encompassing condition. Impressive research has been embraced on RC shafts reinforced with a fortified soffit plate. Tests on RC bars fortified with either steel plates or fiber strengthened plastic plates have uncovered that debonding of the soffit plate from the RC pillar, ordinarily with the solid cover connected to the plate, is a typical disappointment mode in these

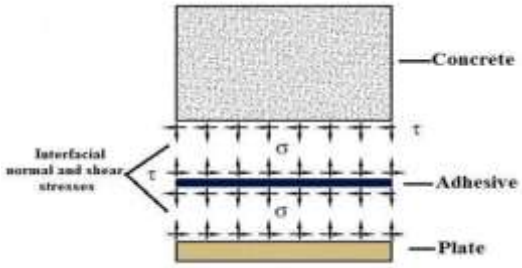
bars. This debonding disappointment mode is fragile and keeps the full use of the rigidity of the fortified plate. It is along these lines imperative to comprehend the system of this debonding disappointment mode and create sound plan rules.

CARBON FIBER REINFORCED POLYMER AND ITS USES

Carbon Fiber Reinforced Polymer (CFRP) is a layer of carbon fiber installed in a polymer which is regularly epoxy. A CFRP framework comprises of the carbon fiber texture or obtained CFRP overlay, the epoxy cement and related groundworks and sealers. Unique components of CFRP are low self weight, high quality, erosion resistance, low warm development and simplicity of use. CFRP have been effectively utilized both inside as a contrasting option to steel support, and remotely as a repairing operator. CFRP has been utilized as a part of fundamental auxiliary designing applications to enhance flexure and shear reinforced likewise constrainment of cement. Predominantly it is utilized to expand the heap bearing limit of old structures that were configuration to endure bring down administration loads than they are encountering today and to repairing harmed structures. CFRP connected to upgrade shear quality of fortified cement by wrapping textures around the segment. This additionally improves the malleability of the segment.

INTERFACIAL STRESSES

From up to said techniques for flexural reinforcing, fortifying of bars by outside plate holding is considered in the present examination. Two interfaces are considered in this technique, one along the solid to glue (AC) interface and the other along the plate to glue (PA) interface. The tractable burdens are to be exchanged from the fortified plate to the solid through the cement layer prompting the advancementof high ordinary and shear worries close plate end along the two interfaces. The burdens in this way created in these interfaces are called interfacial anxieties, they assume a prevalent part in understanding the disappointment method of the plated shafts.



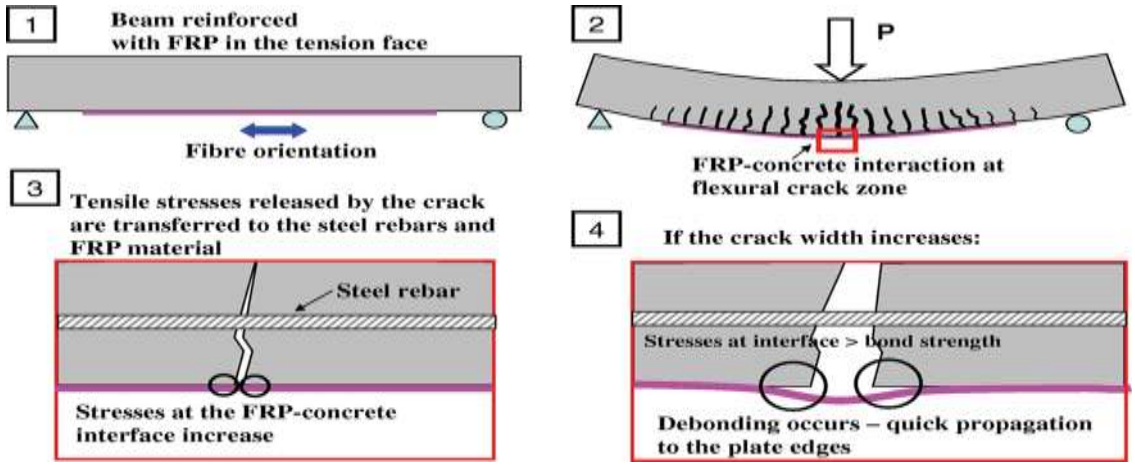
Typical view of interfacial stresses between AC and PA interfaces

MODES OF FAILURE

The plate end debonding (PED) disappointment starts at or close to the plate closes. It shows up in various modes.
1.Concrete cover detachment which happens at the level of the steel strain support beginning from a plate end.
2.Interfacialdebonding at the cement interface which happens more often than not in the solid at a little separation from the cement solid interface.
3.Mixed mode with a blend of (1) and (2).
4.Critical askew split (CDC) started solid cover partition.
5.Critical slanting break (CDC) started interfacial debonding.

The initial three sorts of PED disappointment are seen in RC shafts with plate ending inside the districts where bowing distortion is overwhelming, among which sort (1) is seen to be the controlling mode much of the time. Disappointment sort (2) happens when the plate-pillar interface turns out to be more basic especially when the plate is much smaller than the bar or when the interface quality is weaker either because of frail glue or shameful holding. Disappointment sort (1.5.1)is likewise saw in a couple of cases. Every one of these disappointments are firmly identified with high interfacial

worries between either the composite plate (that is made out of the solid cover and the soffit plate) and the steel pressure plate strain for the most part does not altogether increment after the start of PED disappointment support or the soffit plate and shaft interface, ascribed by geometric intermittence at the plate end together with flexible confound between the pillar and plate. The deliberate plate strain ordinarily does not fundamentally increment after the start of PED disappointment.



Failure modes are observed in externally plated RC beam

METHODOLOGY IN CONCISE

The diagnostic examination process basically comprises of following

1)Identification of Parameters
2)Finite component demonstrating of remotely plated RC shaft
3)Finite component work demonstrating and merging investigation.
4)Analysis of interfacial worries in glue layer.
5)Results and Discussions

OBJECTIVE AND SCOPE OF WORK

The present examination means to explore the debonding disappointment example of reinforced plate that spreads a prescient model by dissecting the interfacial anxiety appropriation along the glue in remotely plated RC shafts utilizing Finite Element PC program ABAQUS. In this investigation an essentially upheld RC pillar reinforced by holding a soffit plate is broke down under consistently circulated stacking and two point stacking conditions.

The primary target of the investigation is:
1.To investigation on the anxiety dissemination along the interface for various geometric properties of plates and cement layer.
2.To analyze the test consequences of pillars that are fortified with steel plates and Fiber Reinforced Polymer plates.
3.To investigation on the anxiety dispersion along the interface concerning position of plate end.

COMPARISION BETWEEN FRP and STEEL PLATING OF REINFORCED CONCRETEBEAMS

Holding steel plates to the surfaces of shafts or chunks has turned out to be progressively well known for enhancing their quality and firmness. In any case, these plates tend to disconnect rashly from the first shaft before the outline quality is come to. Debonding because of a peeling activity is caused by the anxiety fixations instigated in the region of the plate end, which is expected to a limited extent to the

irregularity of the plate. These anxiety focuses rely upon both the connected minute Mend and shear constrain Vend that happen at the plate end. A basic answer for this intricate issue has been found by deciding the peeling imperviousness to every individual anxiety resultant, that is the peeling imperviousness to unadulterated flexure M and the peeling imperviousness to unadulterated shear V. At that point the peeling imperviousness to blends of the anxiety resultants Mend and Vend has been resolved experimentally.

FINITE ELEMENT MODELLING AND ANALYSIS

This area portrays how to do demonstrating and investigation utilizing ABAQUS. It incorporates geometry demonstrating, property and area task, gathering, coinciding, characterizing limit conditions, characterizing associations, and examination.

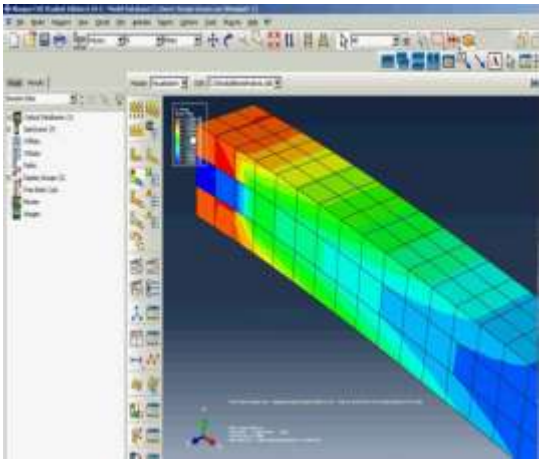
Abaqus FEA (previously ABAQUS) is a product suite for limited component investigation and PC supported building, The name and logo of this product depend on the math device count instrument. The Abaqus item suite comprises of five center programming items.

1.Abaqus/CAE, or "Finish Abaqus Environment with an undeniable root in PC supported building It is a product application utilized for both the displaying and examination of mechanical segments and gatherings (pre-handling) and envisioning the limited component investigation result. A subset of Abaqus/CAE including just the post-handling module can be propelled autonomously in the Abaqus/Viewer item.

2.Abaqus/Standard, a broadly useful Finite-Element analyzer that utilizes certain reconciliation conspire (conventional).

3.Abaqus/Explicit, an uncommon reason Finite-Element analyzer that utilizes unequivocal reconciliation plan to unravel profoundly nonlinear frameworks with numerous intricate contacts under transient burdens.

4.Abaqus/CFD, a computational liquid progression programming application which gives progressed computational liquid elements capacities with broad help for preprocessing and post handling gave in Abaqus/CAE
5.Abaqus/Electromagnetic,a computational electromagnetic programming application which takes care of cutting edge computational electromagnetic issues.



Abacus model

MODULES IN ABAQUS

Part ModuleIt is utilized to characterize the geometry of the individual segments of the model. We can make parts that are local to ABAQUS/CAE, or we can import parts made by different applications either as a geometric portrayal or as a limited component work.
Property of Materials
We need to characterize the properties of a section through areas. When consummation of making a segment, we can utilize one of the accompanying two techniques to appoint the segment to the part in the current viewport:
•By essentially choosing the area from the part and relegate the segment to the chose district.

•By utilizing the set toolset to make a homogeneous set containing the area and allocates the segment to the set. Assembly of Parts Each part that we made is situated in its own particular facilitate framework and is free of alternate parts in the model. Despite the fact that a model may contain many parts, it contains just a single gathering. We need to characterize the geometry of the gathering by making cases of a section and afterward situating the occurrences in respect to each other in a worldwide facilitate framework.

Analysis Step
There are two sorts of examination ventures in ABAQUS: general investigation step, which can be utilized to dissect straight or nonlinear reaction, and direct bother step, which can be utilized just to break down straight issues. Loading Conditions. In ABAQUS the term stack for the most part alludes to anything that actuates an adjustment in the reaction of a structure from its underlying state, including: Concentrated powers, Pressures, Nonzero limit conditions, Body loads, and Temperature (with warm extension of the material characterized).

Meshing - Fundamental cross section is a two-arrange operation:

1.Seeding the edges of the part example

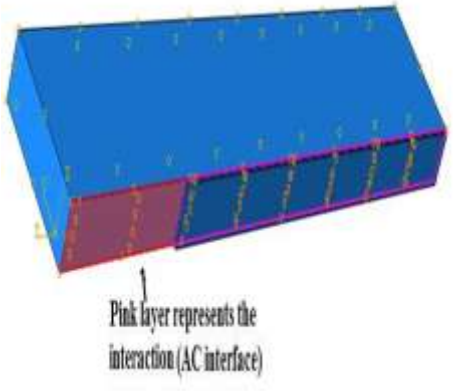
2.Meshing the part example. We need to choose the quantity of seeds in view of the coveted component estimate or on the quantity of components that we need along an edge, and ABAQUS/CAE places the hubs of the work at the seeds at whatever point conceivable. Job-In the wake of presenting the occupation, data shows up by the employment name demonstrating the occupation's status. The status of the issue demonstrates one of the accompanying conditions:
•Submitted while the occupation is being submitted for examination.
•Running while ABAQUS investigates the model.
•Completed when the investigation is finished, and the yield has been composed tothe yield database.
•Aborted if ABAQUS/CAE finds an issue with the information document or the examination and prematurely ends the investigation. What's more, ABAQUS/CAE reports the issue in the message range.
Amid the investigation, ABAQUS/Standard sends data to ABAQUS/CAE to enable us to screen the advance of the employment. Data from the status, information, log, and message records show up in the employment screen discourse box.
Visualization
At the point when the employment finished effectively, we can see the consequences of the examination utilizing the Visualization module. ABAQUS/CAE opens the yield database made by the employment and showcases a quick plot of the undeformed demonstrate.

We can show the distorted model shape and utilize the plot choices to change the twisting scale factor and overlay the undeformed display shape on the disfigured model shape. For little relocation examinations (the default plan in ABAQUS/Standard) the removals are scaled consequently to guarantee that they are obviously noticeable. The scale factor is shown in the state square.

FINITE ELEMENT DESCRIPTION OF MODEL Geometric displaying of RC pillar, Adhesive layer and soffit plate has been done independently utilizing the part module. The material conduct was thought to be homogeneous and isotropic. The material properties, for example, versatile properties were relegated utilizing the property module. Just a quarter demonstrate is set up to break down because of limitations in computational assets. The remotely plated RC shaft show is discretised into a work comprising of

C3D8R component – A 8-hub straight block Element with Reduced mix. Every hub has six degrees of flexibility. Boundary conditionBasically upheld limit condition is considered for the examination. That is, one end of the RC shaft joined with pivot and flip side with roller. In pivoted bolster, all the three relocations (U1=U2=U3=0) along x, y and z bearings are captured. In roller bolster, two relocations (U1=U2=0) along y and x bearings are captured and other one (U3 0) along z course is allowed to move along its hub.
Since, a quarter demonstrate is just shaped symmetry conditions were given at all the essential hubs in both x heading and z bearing. This influences the model work to like a total structure Symmetry condition.

Case-1: Externally plated RC shaft subjected to consistently dispersed load.
Case-2: Externally plated RC pillar subjected to two-point stacking with plate ended inside the steady minute district.
Case-3: Externally plated RC shaft subjected to two-point stacking with plate stretched out past the steady minute district to a point where twisting minute is negligible.
Interaction At this stage the entire FE demonstrate is only a gathering the fortifications, glue layer and the plate are to be reinforced for the solid pillar. For making bond between the disciples different strategies have been received by analysts. The bond can be made by utilizing spring components with firmness equivalent to the underlying youthful's modulus of the glue. Generally an ideal bond by methods for full association can be given between the follower surfaces. In this investigation the later one was embraced. The bond between adherents was assumed as a 'Perfect Bonding'. i.e. There is no slip.
The full cooperation between followers can be appointed by utilizing tie requirement. For making tie imperative the solid pillar surface ought to be considered as ace surface and the cement surface ought to be considered as slave surface. The slave surface ought to have better work measure than the ace surface.



Interaction detail in plated RC beam modelElement type

The component sort picked is C3D8R. C3D8R is a 8-hub direct block component with diminished incorporation. It has six degrees of opportunity at every hub. They are interpretations in x, y and z headings and turns about x, y and z pivot. C3D8R components can be utilized as a part of

Distance from plate end in Mm	Stresses in MPa 4mm mesh	Stresses in MPa 8mm mesh	Stresses in MPa 10mm mesh
0	2.03	1.88	1.68
2	2.26	2.08	1.80
4	1.81	1.76	1.65
6	1.43	1.39	1.31
8	0.83	0.8	0.76
10	0.41	0.39	0.36
12	0.1	0.07	0.064
14	0.096	0.065	0.06

three-dimensional investigation. In ABAQUS/Standard they utilize straight or quadratic introduction and permit mechanical and warm (uncoupled) loadings. These components can be utilized as a part of static and dynamic techniques. These components utilizes decreased (bring down request) incorporation to shape the components solidness. Decreased joining as a rule gives more exact outcomes and essentially lessens running time, particularly in three measurements.

MESH CONVERGENCE STUDY

Lattice is an essential piece of limited component examination. During the time spent investigation uncommon consideration ought to be given to work the model in the most ideal way that could be available. A similar model can be fit utilizing distinctive components estimate. The point is to locate the most proper and productive component size to do the investigation. Finding the most suitable and productive work is exceptionally subject to the computational assets, in light of the fact that as the work gets better more computational assets are required for the examination. So the computational ability of the PC is one of the fundamental factors keeping in mind the end goal to decide the work thickness. Work meeting study is done on the RC bar show which is utilized for the approval. Choosing an ideal work is particularly required particularly in the present examination since the essential suspicion made is that the centralization of interfacial anxieties is more close to the plate end, a fine work is to be expected to watch the anxiety variety. The component estimate is diminished and the work getting better at the every examination. The component estimate is the length of the one component. At each examination, the interfacial anxiety esteems in glue layer with that component measure are computed. **Mesh Convergence Study for interfacial stresses**

VALIDATION

With a specific end goal to build up the limited component demonstrate, reference shaft display is chosen from writing and utilized.

J.G.Teng, J.W.Zhang, S.T.Smith (2001) have done a numerical examination on the interfacial worries in the cement layer through computational approach contrasting and a shut shape arrangement created by Smith and Teng. The impact of different material and geometric properties on interfacial anxieties has been examined. The geometric and the material properties of the shaft display is taken for approval from their investigation. The points of interest of the plated shaft display are as appeared in the figure 3.4.

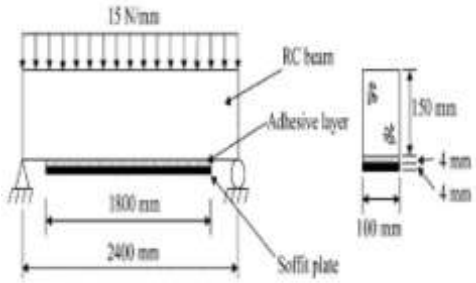


Figure 3.4 Typical details of Plated RC beam Considered for validation

[Ref.: J.G.Teng, J.W.Zhang, S.T.Smith (2001)The limit conditions received for the plated pillar is essentially upheld. It is subjected to a consistently appropriated heap of 15N/mm. The material properties of approving model are given in table 3.2.

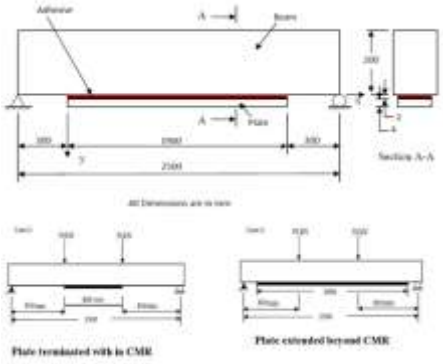
Table 3.2 Properties of validating model

Component	Width, mm	Depth, mm	Length, mm	Youngs modulus, MPa	Poisson's Ratio

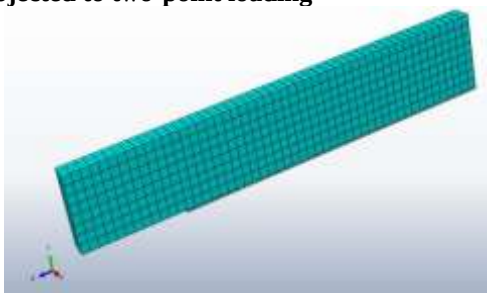
Concrete	100	150	2400	20000	0.17
Adhesive	100	4	1800	2000	0.25
Steel Plate	100	4	1800	200000	0.3

PRESENT STUDY

The material properties given in table 3.3 have been utilized to make the model for breaking down the interfacial worries in the glue layer. The limit condition embraced is basically upheld. The conduct of interfacial anxieties has been examined by considering the impact of different geometric and mechanical properties of the followers. Significant two cases considered in the present investigation are the conduct and impact of interfacial worries close to the plate end for the reason for disappointment when the bar is subjected to consistently conveyed load and two-point stacking. Further, two cases are considered in two-point stacking, for the plate when ended inside the steady minute area and the plate stretched out past the consistent minute district where the twisting minute is negligible. Limited component model of remotely plated RC shaft is produced in ABAQUS to ponder the interfacial anxiety conduct in the glue layer close to the plate end. Every one of the components are demonstrated with C3D8R direct block component. The run of the mill limited component model of the plated shaft is appeared in the figure 3.8.



Typical view of a plated RC beam subjected to UDL andCases considered in plated RC beam subjected to two-point loading



Typical finite element model of the plated beam

Parametric investigation is completed with various geometric properties and distinctive soffit plate material. The progression examination considered in the present investigation is static general. The material properties utilized as a part of the present examination are given in table

Properties of present model

Component	Width, Mm	Depth, mm	Length, mm	Youngs modulus, MPa	Poisson's Ratio
Concrete	130	200	2500	30000	0.2
Adhesive	130	2	1900	2000	0.35
Steel Plate	130	4	1900	200000	0.3
CFRP	130	2	1900	138000	0.21

RESULTS AND DISCUSSIONS

A three dimensional limited component model of remotely plated strengthened solid shaft is created with the material properties said in table 3.3 utilizing ABAQUS. In the present investigation, significance is offered essentially to comprehend the conduct of interfacial worries close to the plate end.

PARAMETRIC STUDY

A parametric report is exhibited here in which limited component interfacial typical and shear stretch conduct are thought about when one of the parameters was differed each time with the various esteems as given in Table 3.3 unless generally expressed to give a more far reaching appraisal of the execution of the plated shafts. The light emission 3.6 was taken as the reference bar.

The parameters changed in the present investigation incorporate

•The glue layer thickness

•The glue layer versatile modulus

•The soffit plate thickness

•The soffit plate material

Loading

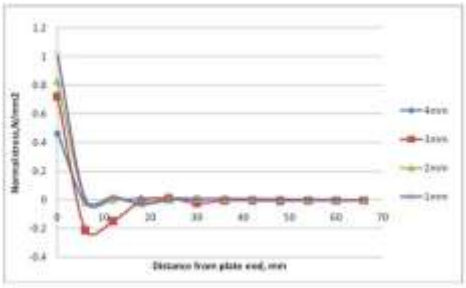
Two stacking conditions are considered in the present investigation

•A consistently disseminated heap of 50KN/m is connected along the length of the shaft as appeared in Figure 3.6 and the parameters are fluctuated in this stacking condition alone.

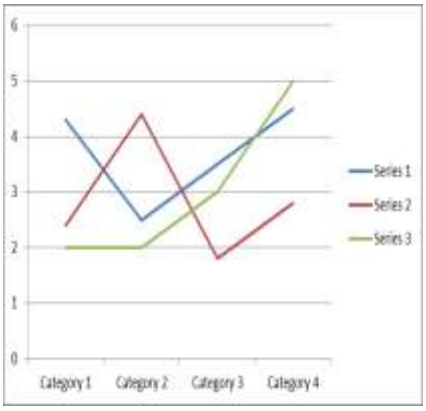
•Two-point stacking of 30KN at each point is connected on the pillar by keeping up the measurements of solid follower steady and by changing the length of plate, one by ending plate inside the consistent minute locale and the other by broadening plate past CMR where twisting minute is negligible as appeared in Figure 3.7.

Effect of Adhesive layer thickness

Interfacial typical and shear stresses were acquired for four distinctive glue layer thicknesses of 1, 2, 3 and 4 mm with every other property as given in Table 3.3. Both the interfacial ordinary and shear stresses are appeared in Figures 4.1 and 4.2 separately for the area close to the plate end.



Effect of adhesive layer thickness on interfacial normal stress

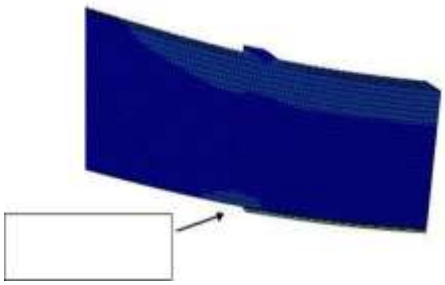


Distance from plate end, mm

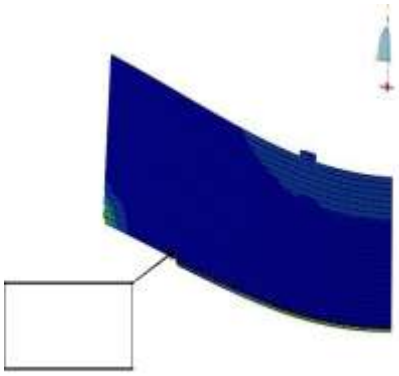
Effect of adhesive layer thickness on interfacial shear stress-It can be seen that reducing the thickness of the adhesive layer leads to an increase in both the normal stress (Figure 4.1) and the shear stress (Figure 4.2). The peak interfacial normal stress occurs near the end of the plate. At the end of the plate, the interfacial shear stress values are slightly tending towards zero. The peak finite element shear stress occurs at a short distance from the end of the plate, rather than at the end of the plate.

Peak interfacial stresses for different adhesive layer thickness

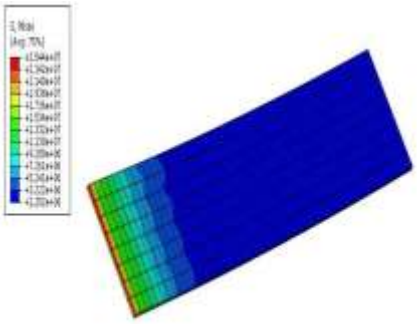
Adhesive thickness, mm	Peak stresses, MPa
1	1.02
2	0.83
3	0.72
4	0.46



Stress contour when the plate is terminated within CMR



Stress contour when plate is extended beyond CMR STRESS CONTOURS



Stress contour of adhesive when plate is terminated in CMR

The observation of stress contours helps to understand the interfacial stress behaviour very easily. The most common pattern of the stress contour has been observed in almost all the cases in the present study with the stresses starting high near the plate end and gradually decreasing along the length of plate. Figure 4.12 and 4.13 shows the stresses observed in adhesive layer.

SUMMARY

A watchful limited component examination concerning interfacial worries in fortified cement (RC) pillars reinforced with a reinforced soffit plate has been managed in the present investigation. The present examination was centered around the conduct of interfacial shear and typical worries in the cement layer close to the plate end. The parametric examination is done when one of the parameters was differed each time with the various esteems as given in Table 3.3 unless generally expressed to give a more exhaustive appraisal of the execution of the plated bars when they are subjected to consistently disseminated stack. Another stacking condition is likewise considered in the present examination i.e. to evaluate the impact of the position of plate end on the interfacial worries under two-point stacking.

CONCLUSIONS

In light of the aftereffects of limited component examination, the accompanying conclusions are inferred.

•In general, it is watched that, Uniform anxiety appropriations in the glue layer as accepted in early existing inexact scientific arrangements are found at a little separation far from the finish of the plate. To examine remotely plated RC shafts for exact assurance of the interfacial anxieties,

a fine work must be utilized so the impact of any further work refinement is decreased to a zone close to the finish of the plate.

•Finite component comes about demonstrated that anxieties shift firmly in the cement layer, specifically close to the finish of the plate.

•Under the activity of consistently disperse stack, the accompanying conclusion are gotten from the parametric investigation.

The interfacial burdens were found to increment with a diminishment in glue layer thickness, and pinnacle push esteems are gotten close to the plate end then the anxiety conveyance is practically uniform somewhat far from end of the plate.

The interfacial anxieties were found to increment with an expansion in cement flexible modulus and plate thickness.

The impact of glue versatile modulus haven't demonstrated any huge variety in glue stresses while, the variety in gluethickness have demonstrated critical effect on stretch dissemination especially close to the plate end.

The substitution of CFRP to steel plate has demonstrated a lot of lessening in top burdens.

•Under the activity of two-point stacking

Termination of plate inside the steady minute area is coming about to extremely solid variety in worries close to the plate end and the pinnacle esteems are high contrasted with instance of which plate reached out past CMR.

It is discovered achievable to end plate at a position where twisting minute is negligible for a superior execution of the bar.

Further parametric examinations for this situation and thought of shear disfigurement impact helps for finish appraisal of stress circulations.

•By considering all the above determinations and existing plan a prescient model can be set up in down to earth approach which helps for better execution of structure.

5.5FUTURE SCOPE OF WORK

An test approach is to be completed with the details of expository model utilized as a part of the present investigation.

Comparative investigations are to be improved the situation Finite component demonstrate and exploratory model.

Consideration of shear twisting impact on interfacial burdens has an incredible breadth in future work.

Values along these lines got are to be confirmed with the current investigative arrangements and conclusions can be proclaimed on the interfacial anxiety effect on disappointment Modes.

REFERENCES

1.ABAQUS client's manual, Version 6.11. (2011). DassaultSystemesSimulia Corp., providence, RI, USA.

2.Stratford Tim, Cadei John (2006) "Flexible examination of attachment worries for the outline of a reinforcing plate clung to a bar", Construction and Building Materials 20 (2006) 34– 45.

3.V. Narayanamurthy, J.F.Chen, J.Cairns, A.Ramaswamy (2011) "Impact of shear distortion on interfacial worries in plated shafts subjected to discretionary stacking", International Journal of Adhesion and Adhesives 31 (2011) 862– 874.

4.J.G. Teng, J.W. Zhang, S.T. Smith (2001) "Interfacial worries in fortified solid bars reinforced with a soffit plate: a limited component think about", Construction and Building Materials 16(2002).1-4.

5.Abu Thomas Zachariah (2006) "Limited Element Modeling of Adhesive Interface amongst Steel and CFRP", Chalmers, Civil and Environmental Engineering, Master's Thesis 2006:61.