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Review of Non-Linear Finite Element Analysis of Steel Plate Retrofitted RC Beam Using ANSYS

Nandhu Prasad[*1], Ramveer Tyagi[2], John Hansdak[3]

[*1]*Integrated M.Tech Student, Department Of Civil Engineering, Dr.K.N.Modi University, Newai, Rajasthan, India.*

[2]*Associate Professor and Head, Department of Civil Engineering, Dr.K.N.Modi University, Newai, Rajasthan, India.*

[3]*Associate Professor, Department Of Civil Engineering, Dr.K.N.Modi University, Newai, Rajasthan, India.*

Abstract

The goal of this paper is to concentrate the writing and numerical audit of the conduct of retrofitted and non-retrofitted bars and think about the outcomes which was done by other researcher's. The retrofitting material utilized here is the steel plate, which is joined to the soffit of the bar. A 3-dimensional nonlinear limited component investigation of the shaft subjected to single point stacking has directed. Diverse solid disappointment parameters, for example, shear exchange coefficients, uniaxial pliable and compressive qualities considered. A full-scale model of control bars, and retrofitted shafts, are molded and comes about analyzed. The principal break stack, disappointment stack, split example and load diversion qualities of the pillars displayed and examined utilizing limited component examination bundle contrasted and the trial comes about. The limited component examination method in this present review is completed utilizing ANSYS 15 Package. The different components utilized in ANSYS to show the fortified solid bar, and additionally the distinctive information sources required, alongside the means to be taken after to accomplish the outcomes is nitty gritty in this paper. Conclusions have been drawn out by contrasting the consequences of the Control and Strengthened shaft. The steel plate retrofitted shaft supposedly had upgraded quality and furthermore contrasted well and the trial information

Keywords: Non linear analysis, Finite Element, Steel plate, Retrofitting, Structure, Strengthened beam, Full Beam, Control beam

I. Introduction

In the calling of auxiliary designing, new contemporary investigates were done utilizing propelled materials to enhance structures considering quality angle. Because of developments the plain bond cement was introduced with steel individuals, and it gives very fulfilling outcomes, however the issue is that the damaging steel part included the plain concrete cement may get eroded on the off chance that it is influenced by dampness content. It can be overcome by new thoughts that developed, and one such kind is retrofitting. Retrofitting can apply on old structures, and structures in the seismic zone to oppose their basic fall. Retrofitting implies the progressions that will occur on anything after it produced. Utilizing composite materials, we can make Retrofitting. We can improve the quality of existing structures against seismic action by doing retrofitting process.

The constituents of the composite materials have diverse physical and substance properties. In any case, when they intertwine, the last material has particularly extraordinary attributes. Indeed, even after the mix, the constituents stay isolated in the material. The innovatively most critical composite are those in which the scattered stage is as fiber. The filaments are either long or short. Long and persistent strands are anything but difficult to arrange and prepare, though short filaments can't be controlled enough for legitimate introduction. The main in business utilize is different sorts of glass, carbon, graphite and Kevlar. Every one of these filaments joined in framework shape either in the constant length or spasmodic length. Polymers like polyester, vinyl ester or nylon are utilized despite the fact that it is typically epoxy. The technique for readiness, the relative extent of filaments to the polymer and the design decides the properties of FRP.

Solid components are customarily performed by remotely holding steel plates to concrete as retrofitting of flexures. This procedure is exceptionally productive in expanding the quality and firmness of fortified solid components, and it has the constraints of being helpless to erosion and difficult to introduce. Most recent improvement in the field of composite materials, together with their innate properties, which incorporate high particular rigidity genuine exhaustion and consumption resistance and convenience, steel plates make them an appealing option in the field of repair and reinforcing of solid components

1.2. Steel plates

There are distinctive methods in retrofitting, for example, steel jacketing, giving extra support and expanding the area measurements, fortifying utilizing fiber fortified polymers, and so forth. Each of these strategies has their significance and is selected in view of the prerequisite and simplicity of use. The above systems are costly, require gifted work and take more term for an application. Gentle steel plates will be one of the options for retrofitting the current structure, which has high youthful's modulus and is bendable, moldable. They are savvy and simple to introduce. They will be accessible in required thickness. They can be painted alongside the example with the goal that it won't show up as retrofitted example.

RCC Beam retrofitted with MS plates

- **Points of interest of steel plates:**
- Causes negligible site interruption
- Negligible change in area measure
- Brisk

- **Burdens of steel plates:**
- Trouble in taking care of substantial plates
- Erosion

1.2. Fibre-Reinforced Polymers (FRP)

Strengthening Fibre is open in both two-dimensional and three-dimensional presentations. FRP permits the arrangement of the glass of thermoplastics to suit particular plan programs. Indicating the introduction of strengthening can build the quality and imperviousness to miss happening of the polymer[1]. Glass strengthened polymers are most grounded and most resistive to misshaping powers when the polymers are parallel to the constrain being applied and are weakest [1] when they are opposite. Along these lines this capacity is on the double both leeway and a confinement relying upon the setting of utilization. Frail spots of opposite can be utilized for normal pivots and associations, yet can likewise prompt material disappointment when production [1] forms neglect to situate the parallel to expected powers legitimately. At the point when powers are applied opposite to the orientation [1] of the quality, and versatility of the polymer is not as much as the network alone.

- **Points of interest of FRP:**
- Light weight, strong, efficient.
- Thin covers.
- Artificially idle.
- High quality to weight proportion.

- **Detriments of FRP:**

Confuse in elasticity with that of cement.

FRP retrofitted beam

Since its tensile strength decreases with increasing modulus, its strain at rupture will also be much lower. Because of the material brittleness at higher modulus, it becomes critical in joint and connection details, which can have high stress concentrations. As a result of this phenomenon, carbon composite laminates are more effective with adhesive bonding that eliminates mechanical fasteners.

II. LITERATURE REVIEW

General

The literature review will focus on contribution related to non-linear finite element analysis of reinforced concrete beam as well as experimental programs by various researchers and also literature available related to the present area of study.

Bhushan lal[2] et al. (2003): This paper concentrates the viability of CARDIFRC as a retrofitting material. Another retrofitting method in view of a material good with cement was produced at Cardiff University[2]. This get ready elite fibre strengthened cement blends HPFRCC, assigned CARDIF[2]. They are portrayed by high pliable/flexural quality and high vitality ingestion limit, i.e., flexibility. The extraordinary attributes of CARDIFRC make them especially appropriate for repair, healing, and overhauling exercises, i.e., retrofitting of existing solid structures. Two sorts of bars contrasting just by the fortification were utilized for Stages I and II of the exploratory program. The bars in Stage I was fortified in flexure just with a solitary 12 mm rebar, though in the shafts tried in Stage II, stirrups—comprising of 6 mm twisted steel bars set at 65 mm dividing—were likewise given in the shear ranges of the pillars. As no shear fortification was given in the bars tried in Stage I, both methods of disappointment, i.e., shear and flexural were normal. In any case, the pillars tried in Stage II were planned in such a way to flop in flexure [2]. Every one of the shafts were produced using a standard solid blend and were 1,200 mm long, 100 mm wide, and 150 mm profound. The retrofit materials, CARDIFRC Mix I and Mix II were given a role as level strips in 1,030 mm long and 100 mm wide steel molds. In stage I, of the seven shafts retrofitted with one strip just on the strain confront, four bars bombed in flexure, two in shear, and one in a mix of flexure and shear. Every one of the shafts fizzled at any rate equivalent to the normal disappointment heap of the control bars[2]. The six pillars retrofitted with three 16 mm strips all bombed in unadulterated flexure. In stage II, the four shafts that were retrofitted with one strip just on the strain confront all flopped in flexure. In any case, in a large portion of the pillars, three out of foursome indications of shear pain as small corner to corner splits were seen toward the finish of the strips close to the backings. These breaks proliferated towards the closest stacking point and brought about a neighborhood drop in the heap.

The mechanical properties of CARDIFRC Mixes I and II are fundamentally the same as; in this way there is no genuine distinction in the conduct of the pillars retrofitted with both of these blends. The minute resistance and load-redirection reaction of the bars retrofitted utilizing this method can be anticipated diagnostically, giving that the strain solidifying and pressure softening reaction of cement and CARDIFRC are appropriately considered. The procedure portrayed in might be utilized when there is a need to enhance the toughness of existing solid structures, as CARDIFRC blends are exceptionally sturdy due to their profoundly thick microstructure [1].

Anthony J Wolanski[3] (2004): In this paper, a gentle steel fortified solid bar with shear and flexural fortification was retrofitted with CFRP and tried tentatively. A scientific model of the same was made utilizing ANSYS and broke down. Disappointment stack anticipated by the product was near that acquired tentatively. Additionally, Deflections and worries at the line alongside first and dynamic breaking of FEM model contrast well and trial information.

Robert Y Xiao[4] et al (2006): This paper examines the conduct of pillars retrofitted with different kind of stringy cement at the strain and pressure zones of fortified solid bars intended to bomb in flexure, the retrofitted shafts were contrasted and the controlled plain strengthened bars as far as extreme quality, diversion, breaks conduct and disappointment mode. Three sorts of components have been utilized as retrofitting materials; polypropylene, steel, and cross breed (a mix of polypropylene and steel). The properties of the materials utilized are polypropylene fiber (S-152 High-Performance Polymer HPP), with Specific Gravity of 0.91, the elasticity of 190MPa and the fiber length 45mm with the pleated shape. Steel fiber (Xerex Steel Fiber) has a base Tensile Strength of 825MPa and fiber length of 35mm with the creased shape. The fiber volumes utilized as a part of the solid blends are; 0.6% for steel, 0.8% for polypropylene and half and half with volumes of 0.2% and 0.4% for steel and polypropylene individually.

Contrasted with plain fortified bars, the outcome demonstrates an expansion in a definitive connected load up to 6.11%. All pillars retrofitted with stringy cement on base show an expansion of a definitive heap of 3.97%, 4.99% and 6.11% for steel, polypropylene and cross breed sinewy cement separately. Bars, which were retrofitted with stringy cement on top, encountered a dropping in an extreme heap of 5.94% when utilizing steel concrete because of shear disappointment, while an expansion of 3.05% and 5.44% was gotten for utilizing polypropylene and half and half on top individually. Among those stringy cements which were utilized as retrofitted materials, shafts with half and half sinewy cement played out the most elevated extreme load for both retrofitted segments at the top and base. All pillars retrofitted with stringy cement on top carried on in a pliable way. Bars retrofitted with steel and polypropylene sinewy cement at the top divert generally less, bends were rising customarily up to the versatile point, and thusly, bends were slipping to a specific point, at that point rising again and increasing more loads. The conduct of the slipping in bends was because of shear disappointment. On the other hand, the climbing part in bends was because of the resistance of steel fortification to the connected burdens until bars reach to disappointment. Conversely, shafts retrofitted with half and half stringy cement divert more with flexible conduct. Pillars retrofitted on the base with all kind of stringy cement have performed noteworthy load-diversion conduct. Pillars were stiffer contrasted with plain strengthened bars. All retrofitted Beams at the base have comparable splitting and smashing examples to plain fortified shafts. Be that as it may, shear breaks were started first. Prior to the disappointment, flexural splits were started and spread with the expansion of load. Subsequence, pillars bomb in flexural.

Amer and Mohammed[5] (2009): This paper investigations hypothetically by limited components techniques by ANSYS bundle on FRP retrofitted pillars. A test explored six shear insufficient rectangular light emissions area 150×250mm including two control shafts B1 and B2. Impact of bearings of FRP composites on RC shafts was considered since it is an orthotropic material. A definitive shear quality estimations of retrofitted bars by trial esteems were great concurrence with shear quality examined by limited component display, inferring that the carbon was opposing more load than glass.

Vasudevan[6] et al(2011): Directed a review on cement constitutive properties, work thickness, utilization of steel pad for the backings and stacking focuses, the impact of shear support on flexural conduct, joining criteria, and effect of the rate of fortification on strengthened solid shafts utilizing ANSYS 12.Beam model utilized by Wolanski (2004) was utilized for the study.It was said that the exactness and the merging of the outcomes chiefly rely on upon the work thickness. An ideal work thickness is touched base by directing couple of quantities of trial examinations by shifting the work thickness. To anticipate the nonlinear conduct, the aggregate load is to be partitioned into arrangement of load augmentations (or) load steps. To beat the anxiety focus issues at the support and stacking focuses steel pads were given at the backings and the stacking focuses. The impact of steel pad on the conduct of RC pillars was considered and expressed that the reaction of the shaft remains for all intents and purposes the same with and without the pads. Be that as it may, by looking at the anxiety form graphs and for the point by point examine on stress variety at the stacking and bolster area, the steel pad must be incorporated into the displaying. Close to the main splitting stage, steel yielding stage and at a definitive stage bring down union limits are to be utilized for precise forecast of conduct.

The aggregate load is to be separated into some reasonable load steps (stack increases) by leading a couple trial investigations until a smooth load versus avoidance bend is acquired. The underlying splitting conduct is not changing much with shifting rate of fortification. Be that as it may, in the yielding steel level, the variety is much, and a definitive quality can be shifted by changing the rate of fortification. The pressure and shear fortifications are to be absolutely joined utilizing a discrete demonstrating procedure to get the right conduct. A relative review was attempted to concentrate the impact of barring shear fortification on the flexural conduct, and it was reasoned that for the more precise expectation of nonlinear conduct RC bars, the shear fortifications are to be incorporated into the displaying.

Umesh Basappa[7] et al.(2012): In this paper, the break demonstrating approach for carbon fiber fortified polymer (CFRP) reinforced RCC pillar by playing out a three-dimensional nonlinear limited component investigation of the bar subjected to four point stacking. Most importantly, an unstrengthened bar with and without holder bars are considered for the investigation and results are contrasted and test comes about. In the following case, a CFRP fortified RCC pillar is considered for examination. A parametric review is performed considering an alternate length of CFRP utilized for flexural fortifying of shafts, demonstrating CFRP as Isotropic and Orthotropic and fluctuating the range of steel support in strain area.

Table 2.1: Comparison of FEA and experimental results

	Load at first cracking (kN)	Average failure load (kN)	Average Deflection at failure (mm)
Experimental	**20.43**	**74**	**93**
ANSYS (without Hangers)	**18.735**	**84**	**128**
ANSYS (With Hangers)	**19.3**	**77**	**26**

The break design relies on upon the range of longitudinal fortification gave. The bigger the territory of support pillar neglects to demonstrate greater breaks (all the more cautioning) and littler the range of fortification bar neglects to demonstrate a couple splits (less cautioning). Henceforth, shaft with holder bar was considered to concentrate the split example for the different region of support and in the meantime under, adjusted and over segments are distinguished by looking at the mechanical conduct of the pillar. Afterward, the flexural limit of RCC bar is post reinforced utilizing CFRP. A parametric review was likewise made considering different lengths CFRP. In another review, Two distinctive material properties were considered for the CFRP: isotropic and orthotropic. It is accepted that an impeccable holding exists between the RCC pillar and CFRP and it was watched that CFRP with orthotropic property demonstrated more compelling than isotropic property.

Jayajothi[8] et al. (2013): In this paper, the nonlinear Finite Element Analysis (FEA) was performed to recreate the conduct of disappointment methods of Reinforced Concrete (RC) bars fortified in flexure and shear by Fiber Reinforced Polymer (FRP) covers. Four bars were demonstrated in FEM programming utilizing ANSYS. In those four shafts, two bars were control pillars without FRP, and other two bars were Carbon Fiber Reinforced Polymer (CFRP) fortified bars. A fourth of the full pillar was utilized for displaying by exploiting the symmetry of the bar, stacking and limit conditions. The heap diversion plots, break designs gotten from numerical reviews indicate great concurrence with the trial plots. A definitive load conveying limit of all the fortified shafts is higher when contrasted with the control pillars, which demonstrates that CFRP texture appropriately clung to the strain face of RC bars can upgrade the flexural quality significantly. The fortified shaft showed an expansion in flexural quality of 18 to 20 percent for a solitary layer. The heap conveying limit of the fortified pillar which was reinforced utilizing a solitary layer U-wrap CFRP was observed to be higher when contrasted with a shaft which was reinforced utilizing a CFRP plate on the pressure face of the bar.

Dr.H.N.Jagannatha Reddy[9] et al. (2013): This paper concentrates the retrofitting of RC bars utilizing common FRP wrapping. In this paper, silk fibre is utilized as retrofitting material. The properties of silk fibre are:

- Specific gravity [g/cm3]: 1.32 to 1.33

- Water absorption [%] : 80
- Tensile strength [M Pa] : 130
- Modulus of elasticity [G Pa]: 9

From the experimental test results of nine beams and load v/s deflection curves the following conclusions have drawn:

- Strengthening by silk fiber composite at pressure zone bars have conveyed the more extreme load by around 39.77% contrasted with that of control bar specimen[9].
- Strengthening by silk fiber composite at flexure zone pillars have conveyed the more extreme load by around 36.82% contrasted with that of control shaft specimen[9].
- A definitive load conveying limit was observed to be high for shafts retrofitted with NSFRP composites when contrasted with control beam[9].
- The flexural reinforcing gave was high, which made the bars solid and firm, due to which the greater part of the shafts couldn't bomb by flexure, so the flopped by sheer[9].

Tej Sai M[10] (2014): In this paper retrofitting of fortified solid pillars utilizing MS steel plates was considered. For this three examples were taken. The principal example is the control test, which is composed according to IS 456:2000. The second and third examples are likewise a similar control example which is retrofitted utilizing 2 and three layers of MS steel plates. A static load was connected at the focal point of the pillar up to a controlled load. The non-direct examination was performed. The exhibitions of the retrofitted bars were contrasted and the control example both tentatively and in ANSYS.

- It was watched that every one of the shafts were flopped because of shear
- Ultimate heap of the retrofitted shaft with 3 Ms plates is moderately high contrasted with the control bars.
- Retrofitted shafts demonstrated lesser relocation contrasted with control pillar at comparative load interims.
- Load versus uprooting comes about acquired from the limited component examination is like the test comes about.

Tejaswini and Dr.M.V. Rama Raju[11] (2015): The point of this paper is to contrast test comes about and the ABAQUS comes about. At first, Laboratory tests are done on a light emission x 200 x100 mm of M30 review concrete for plain, under, adjusted, over fortified segments. Limited Element Analysis (FEA) have likewise been performed utilizing ABAQUS for the model geometry considered in the test examine. The numerical outcomes from the FEA are contrasted and the test results[11].

The following conclusions can be stated based on the evaluation of the analyses of the calibration model:

- Deflections and stresses at the line alongside starting and dynamic splitting of the limited component show contrast well with trial information gotten from a fortified cement beam[11].
- A definitive load conveying limit of Plane solid pillar is 0.14 times under-strengthened bar.
- The disappointment system of a fortified solid bar is demonstrated great utilizing FEA and the disappointment stack anticipated is near the disappointment stack measured amid test testing[11].
- From the scientific examination, it was watched that under fortified proportion is the best sort of support proportion among the others since it indicates most prominent cautioning zone before failure[11].
- In under-strengthened shaft most extreme components achieve extreme anxiety contrast with over fortified solid pillar.

III. CRITICAL REMARKS

Following conclusions were drawn from the results obtained:

- Fortifying of RC bars utilizing FRP composites and steel plates, which are chiefly centred around sort, measurements, introduction, number of layers of FRP composites, number of steel plates, impact of crawl, the variety of fortification and its impact on reinforcing, the impact of FRP and steel plate lengths and displaying techniques[R12].
- A large portion of the works of writing propose utilizing SOLID 65 for solid, LINK 180 for steel fortification, SOLID 185 for stacking plate, retrofitting plate and bolster plate.

- ANSYS programming is equipped for anticipating a definitive load conveying limit of fortified solid bar with awesome exactness.
- For cement, SOLID65 and for steel support, LINK180 gives genuinely great outcomes
- The outcomes acquired from ANSYS are reliable with that accessible in the writing.
- A definitive disappointment stack gotten on account of control shaft was in great concurrence with the relating brings about the writing with a mistake of 0.7 %.
- A definitive quality of the retrofitted pillars was observed to be higher than the control bar.
- Basic disappointment may happen in FRP materials when:
- Malleable powers extend the network more than the farthest point, making the material shear at the interface.
- Ductile strengths close to the finish of the filaments surpass the resilience's of the matrix[r13], isolating the strands from the grid.
- Tractable powers can likewise surpass the resilience's of the strands making themselves break prompting material disappointment.

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