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Literature Review on Deep Beam Analysis for Multi-Storied Building

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Abstract

In this section, center is for the most part towards the investigation of reinforced concrete deep beams whose a/d proportion is under 1.0 with or without web support. Before continuing to think about the deep beams, the foundation of shear conduct is also checked on at first. The part of shear conduct in steel reinforced concrete deep beam members is talked about in this section. The as of late presented hypothetical concepts clarifying the shear conduct has also been considered for this audit. Rundown Considerable advance has been made in the previous century in the outline of RC members subjected to shear. Some of the essential contributions to contemplate the shear conduct, for example, Kani's model, altered compression field hypothesis, variable truss point display, pivoting edge softened truss display have been examined. Notwithstanding a tremendous number of works done on shear conduct of beams, there is still no bound together solution to foresee the shear quality of a beam independent of whether it is slim, short or deep beam. In any case, inquire about chip away at shear conduct of thin beams is as of now did to discover a brought together expression for shear quality that could be acknowledged and adjusted commonly.
Keywords: Literature review, RC Deep Beam, a/d ratio, shear

I. Introduction to Deep Beams and its Concept

Concrete deep beams convey substantial load inside a short supported traverse. As such, a reinforced concrete deep beam can be communicated as a beam having a profundity practically identical to the traverse length. They have wide applications and are utilized as a part of foundations works, tall structures, seaward structures, and so on.

The conceptual changeover from standard beam conduct to deep beam conduct is expressed to be uncertain and has been very much clarified in a book composed by Kong (1990). He has mentioned that the transition from a standard beam conduct to a deep-beam conduct is loose and is hard to precisely anticipate the purpose of progress in the conduct. Reinforced concrete deep beams contrast from different beams fundamentally in their conduct to take up the heap. Because of the geometry of deep beams, the disappointment in deep beams is completely administered by shear instead of flexural disappointment. Prior to a deep beam could take up its full flexural quality, diagonal breaks are framed which tend to cause shear disappointment. Consequently, shear quality is considered as a critical factor in the outline of concrete deep beams. The simple fundamental belief system of arranging a concrete deep beam has not turn out to be generally common. The outline of reinforced concrete deep beam for shear which is embraced by different plan codes varies essentially in characterizing RC deep beams. Distinctive nations take after different belief system to characterize a deep beam in their applicable code books. Be that as it may, in this examination the classification of deep beams depends on ACI-ASCE Committee 445(1998) which expresses that a beam with shear traverse to-profundity proportion (a/d) under 1.0 as a "deep beam" and a beam with a/d surpassing 2.5 as a normal shallow beam. Any beam between these points of confinement ($1 < a/d < 2.5$) is named a short beam.Elements Influencing Shear Behavior in RC Deep Beams In view of the audit made on before look into work done on deep beams, one can surmise that the indispensable parameters that control the shear quality in deep beams are:

1) Effective depth (d)
2) Width of the beam (b)
3) Effective span (le)
4) Shear span (a)
5) Cylindrical compressive strength of concrete (fc’)
6) Yield strength of horizontal web reinforcement
7) Yield strength of vertical web reinforcement

8) Reinforcement ratio of main tension bars

The basic conduct of deep beams has been turned out to be distinctive when contrasted and slim or short beams. One of the imperative parameters controlling this change is its 'shear traverse to compelling profundity' (a/d) proportion which relies upon the profundity of the beam. Since this proportion is little in deep beams, there is a noteworthy change in the strain distribution over the deep beam's profundity. This variation of strain is non-direct and isn't found in normal slim beams. Shear deformation which is unimportant in normal beams is considered to be generous in deep beams and consequently it can't be disregarded as this factor is also associated with the profundity and powerful traverse of the beam. It has been demonstrated by numerous specialists that the width of the deep beam expands its solidness and shear quality and lessens the parallel clasping. Considerable measure of work has been done under the title "estimate impact" of reinforced concrete deep beams. Concentrates on the impact of web reinforcement quality on the shear conveying limit of beams have been done by numerous scientists. Web support of various sort of materials, shapes and orientation has been tentatively attempted in deep beams in numerous prior works.

A. Earlier Studies on Shear Behavior of RC Deep Beams

De Paiva and Siess (1965) conducted investigates little beams having a compelling profundity scope of 150 mm to 300 mm and with a little "shear traverse to-profundity" proportion in the scope of 0.7 < a d < 1.3. This examination was done by shifting the transverse reinforcement proportion from 0 to 1.4%. In view of this examination the accompanying focuses were concluded:

1) By including the vertical and/or slanted stirrups the slanted splits formation can't be modified. Such an addition also has next to no impact on a definitive quality.
2) By giving more vertical stirrups deflections at a definitive stack was observed to be lessened.
3) A higher stacking limit was seen beyond slanted splitting for beams with little shear traverse to-profundity proportions without shear reinforcement.
4) They concluded by saying that for beams with little 'shear traverse to-profundity' proportion, transverse reinforcement has no impact on beam's quality. This was framed because of the philosophy that a single direct swagger shaped between the stacking point and the bolster reaction in which the transverse support was expected to have no part in changing the beam's quality. By the by, they have expressed that an expansion in the transverse reinforcement can decrease split widths.

Leonhardt and Walther (1966) conducted tests on nine just supported deep beams and two continuous deep beams. The beams tried were with a 'traverse to profundity' proportion extending between of 0.9 to 1.0. The tests conducted by these specialists were on one of the biggest deep beams ever tried having a profundity of 1.6 meters. Their tests demonstrated that deep beams which encounter a uniform tension power in the base fundamental support create a "tie-curve" action. In light of their test outcomes, they recommended that it isn't conceivable to expand the shear limit of deep beams by giving additional web support. This was anyway negated by later scientists. They also watched that for a 'general length to general profundity' (L/D) proportion break even with to1.0, the horizontal web reinforcement appropriated over roughly 1/5 to 1/10 of beams general profundity (D) was observed to be more powerful in countering the shear splits. They also showed that on account of beams loaded at the base, the vertical or slanted shear stirrups are considered to be altogether imperative in taking up the shear stack. The scientists have also communicated the significance of specifying the harbor zone of the primary longitudinal support as playing a critical part in the plan of deep beams. They also watched that at extreme loads, the deflection estimated along the base harmony of the beams was little and in this way contrasted with conventional beams, deep beams had more solidness. European concrete code panel (1970) and the CIRIA Guide 2 (1977) figured the essential outline of deep beams in light of their work. Ramakrishnan and Ananthanarayana (1968) conducted tests on tried reinforced concrete deep beams having a 'traverse to profundity' proportion going from 0.9 to 1.8. Testing was done on twenty six deep beam examples out of which twenty two beams were with no web reinforcement. The measure of steel web support gave in the rest of the beams was extremely less. They watched that the majority of the beams bombed because of shear. In view of their observations an expression for the shear quality of reinforced concrete deep beams was proposed which depends on the part quality of the concrete. They concluded that shear disappointment in deep beams was nearly the same as that of shallow beams with in a 'shear traverse to profundity' proportion of not exactly. The primary driver of shear disappointment in deep beams is because of part of concrete as saw in a round and hollow split malleable test.

Kong et al (1970) conducted investigates basically supported deep beams to think about the impact of web support. The exploration destinations were the traverse profundity proportion and seven sorts of web reinforcement on deflections, break widths, split examples, disappointment modes and extreme loads in shear. An aggregate of 35 reinforced concrete deep beams were tried. Keeping the traverse constant and by changing only the profundity of the beam, all beams were tried inside a scope of 1 to 3 of 'over all traverse to profundity' (L/D) proportion. The beams were tried under two point stacking until disappointment. From their test outcomes it can be concluded that deflection in deep beams can be generously lessened by a reasonable measure of horizontal web reinforcement set near the base of the beam. Also it is particular from their examination that with firmly separated horizontal web reinforcement, the deflection of the beam can be limited. They concluded by expressing that the viability of horizontal web reinforcement diminished with increment in general traverse to general profundity' (L/D) proportion and 'clear shear traverse to by and large profundity' (x/D) proportion.

From this examination they concluded that,

1) The firmly divided horizontal web reinforcement close to the base of the beam was exceptionally compelling in controlling the split width.

2) The shear reinforcement to control breaks and deflections was especially dependant on the unmistakable shear traverse to-profundity proportion. At the point when the unmistakable shear traverse was bigger than the powerful profundity (x/D > 0.35) vertical stirrups were more compelling in controlling the split widths. At the point when the unmistakable shear traverse was more prominent than the successful profundity (x/D > 0.7) vertical stirrups were more compelling than the horizontal bars or orthogonal reinforcement set in two directions.
3) The essential driver of disappointment watched was diagonal splitting and pounding of the compression swagger between the bearing bolster and the connected load.

Smith and Vantsiotis (1982) did an extensive variety of probes concrete deep beams to explore the impact of web reinforcement and 'shear traverse to successful profundity' proportion in contributing to the shear quality of deep beams. Testing was conducted on fifty-two just supported deep beam examples under two point top burdens. All the beam examples which were tried had a rectangular cross section. Five of the fifty-two beams were given without web reinforcement. All beams which were tried were gathered into four arrangement based on their 'shear traverse to successful profundity' (a/d) proportion. The (a/d) proportions so picked were 0.77, 1.01, 1.34 and 2.01. Both vertical and horizontal web reinforcements were given as shear reinforcement, the separating of whichwas also considered as a variable separated from the 'shear traverse to powerful profundity' proportion.
The conclusions touched base at were:

1) All beams by and large failed in shear.
2) No critical change in the disappointment mode saw between distinctive arrangements.
3) The utilization of least measure of vertical and horizontal web reinforcement decreased the split width and deflection.
4) All in all, the web reinforcement expanded a definitive shear quality for all beams that were tried.
5) The impact of vertical web reinforcement was more prominent over a/d < 1.0.
6) The horizontal web reinforcement had more impact in beams with a/d <1.0
7) Concrete quality has a more prominent impact over a definitive load limit, particularly for beams with a/d <1.0.

Lehwalter (1988) conducted probes sixty essentially supported deep beams examples under three direct bowing toward examine the limit of the compression struts, which were intended to flop in shear. In the first period of the test the qualities of the total, the shear span depth proportion a/h (0.5 < a/h < 1.5), and the beams over all profundity were made as variable parameters. The impact of web reinforcement on the bearing limit was examined in the second period of the investigation. The impact of web reinforcement put under various conditions was examined. Beams with horizontal web reinforcement conveyed over the web were at first researched, and then beams with horizontal web reinforcement concentrated at the highest point of the beam were inspected. At long last beams with vertical web reinforcement dispersed over the web portion of the beam were analyzed. To research the impact of the shear traverse profundity proportion some of the beams were tried with differing 'a/h' proportion running in the vicinity of 0.5 and 1.5. In addition to the above, test were conducted to think about the impact of variation of profundity on a definitive quality of the beam by changing the stature of the beam between 200 to1000 mm. The observation was that the slanted splits began framing when the connected load achieved near 45-half of a definitive load. They found that the shear traverse profundity proportion 'a/h' affected a definitive quality. A definitive quality quickly diminished with expanding in 'a/h; proportion.

The sort of total or the most extreme molecule distance across of total in concrete was found to have no impact as indicated by their observations. The examinations comes about because of their second period of test demonstrated that the shear quality was affected by web reinforcement. A slight increment in quality was found with expanding horizontal web reinforcement. They watch that when the a/h proportion was diminished, the adequacy of vertical web reinforcement diminishes. While considering the profundity as a variable parameter, they conclude that in beams tallness don't impact the shear quality of beams with differing web reinforcement.

Tan et al (1995) contemplated the impact of variation of a/d proportion on the shear quality of deep beams. Nineteen basically supported deep beams were tried in this work. The shear limit of beams were inspected under eleven distinctive 'shear traverse to successful profundity' proportions extending from 0.27 to 5.38 for fluctuating concrete quality running from 50 to 68 MPa. All examples had uniform cross-section and were given same longitudinal and shear reinforcement. The ranges were differed to acquire the coveted traverse profundity proportion. Beams at the lower scope of the a/d proportion were seen to flop because of unadulterated shear condition. It was seen by scientists that when the a/d proportion was expanded the disappointment mode changed from shear to 'flexure-shear' method of disappointment.

B. Effect of Web Reinforcement in Deep Beams

Kong et al (1994) conducted analyses to for the most part think about the impact of high quality concrete (HSC) in the shear conduct of deep beams. The variable parameters considered for this examination were the concrete quality, the 'shear traverse to-profundity' (a/d) proportion and the slimness proportion of beam examples. A sum of 30 beams tried which were intended to flop in shear. An assortment of beams were tried which can be gathered as basically supported, continuous, slim or stocky beams. The test outcomes were contrasted with predictions given in numerous outline codes to think about the shear stack at disappointment. The 'shear traverse to-profundity' proportions received went in the vicinity of 0.22 and 1.50. The quality of the concrete solid shape went from 43 to 96 MPa. They watched that the primary split created was a flexural break, and later the diagonal slanted splits created and at last the beam fizzled by squashing which was like the conduct of deep beams. The sorts of disappointments saw were diagonal part, diagonal compression swagger squashing and on occasion, bearing disappointment. They also saw that there was a sudden increment in the beams' deflection consequent to the formation of starting slanted split especially in beams with web reinforcement. They concluded by communicating that there was no significant change in the shear conduct of the deep beam examples cast with normal quality contrasted with those deep beams with high quality aside from that the disappointment indeep beams with high quality concrete was further weak in nature. They also concluded by communicating that the web reinforcements were generally productive in deep beams when set opposite to the diagonal split insignificant regardless of whether they are just supported or continuous, or stocky or thin. In addition, they expressed that both just supported and continuous examples demonstrated comparative shear conduct. Also, they communicated that the horizontal web reinforcement was more compelling in countering shear for basic and continuous deep beams.

Braestrup (1990) examined the shear quality of deep beams by utilizing the hypothesis of versatility. In his examination the lower and upper bound methodologies are examined. He concluded that the hypothesis of pliancy for basic concrete gives understanding into the conduct of deep beams at disappointment, in addition to giving reasonable predictions of a definitive burdens. He conclude by communicating that for steeply slanted shear disappointment plane in beams with low a/d proportion, the horizontal web reinforcement is more powerful and this was only the switch in beams with high a/d proportion. Ashour et al (2002) proposed an observational displaying got by utilizing the hereditary programming to anticipate the shear quality of strengthened concrete deep beam. The different parameters impacting the shear quality of RC deep beam was broke down utilizing hereditary programming.

The accompanying focuses were concluded in their model investigation:

1) The shear quality was found to increment as the shear-traverse to profundity proportion was diminished, which demonstrates that the shear quality is contrarily proportional to the 'shear traverse to profundity' proportion.
2) The 'shear traverse to profundity' proportion and measure of the fundamental longitudinal reinforcement affects the shear quality of RC deep beams.
3) The primary longitudinal base reinforcement which has an impact over the shear quality was observed to be only till a certain point of confinement, beyond which there appear to be no impact on the shear quality.

Zararis (2003) proposed a hypothesis on shear compression disappointment in deep beams which depends on the examination in split reinforced concrete members along with the inner powers that are at the diagonal shear breaks. In view of this investigation a formal hypothesis to portray the shear quality in deep beams was proposed. The hypothesis was utilized to foresee the profundity of the compression zone over the basic diagonal split and also a definitive shear limit of deep beams with or without web reinforcement. The examination concluded that the contribution of the horizontal web reinforcement to the shear quality of a deep beam is unimportant. The proposed hypothesis a predicts with exactness the exploratory observations for a definitive shear of deep beams with different qualities of concrete, primary steel proportions, shear reinforcement proportions, and shear traverse to profundity (a/d) proportions in the vicinity of 1.0.

C. *The Shear Transfer Mechanism*

1) *Aggregate Interlocking*

Tottori and Wakui (1993) tentatively examined the shear limit of concrete beams utilizing FRP as flexural and shear reinforcement. In their examinations CFRP composite links were utilized as longitudinal reinforcement. Shear reinforcement as spirals made of GFRP,AFRP, CFRP and Vinylon FRP bars were utilized as a part of their test examples. To assess the dowel limit of CFRP flexural reinforcement, examples were extraordinarily intended for tried. With various kinds of shear reinforcement and with various combinations, numerous beams were tried for shear. Strain checks were introduced on the FRP spirals to quantify the strains and compute the shear constrain contributed by the shear reinforcement. They could conclude that the shear compel conveyed by concrete in the compression zone and total interlock were identified with the tractable solidness of the longitudinal reinforcement. Further, the contribution of concrete to the shear opposing power was seen to be equivalent to the shear breaking heap of the beams which is computed in light of the deliberate shear drive contributed by the FRP spirals.

Raffaello Fico et al (2007) in their work have examined about the significance of the total's mechanical interlock which partakes amid shear exchange over a split in the ductile zone. This total interlock represents around 33% and half of the measure of shear limit of uncracked concrete as assessed by Taylor et al (1970). The measure of shear additionally gets lessened when the split width increments because of expanded stacking as expressed by Walraven et al (1981). They have concluded that the total interlock is a function of the break unpleasantness and the split width which relies upon the most extreme total size and on the reinforcement firmness individually. Also, in their examination they have mentioned another noteworthy function impacting the total interlock because of the concrete quality. Assist in their work they have expressed that the aggregate firmness of FRP RC members lessens because of lower strain esteems and higher reinforcement proportion of FRP bars when contrasted with steel RC members. This lower firmness makes the members to redirect bigger and make more extensive splits in the concrete. At last, this prompts the conveying of littler measure of shear drive by total interlock in FRP-fortified members.

Razaqpur et al (2004) in their investigation have tried seven RC beams in bowing to decide the concrete contribution to their shear obstruction. All the RC beams had only flexural reinforcements and there was no shear reinforcement utilized as a part of their tests. The factors considered in their tests were the shear traverse to profundity proportion fluctuating from 1.82 to 4.5 and the flexural reinforcement proportion, differing from 1.1 to 3.88 times the adjusted strain proportion. The test outcomes were contrasted with the qualities acquired by utilizing the different plan codes. At last, they concluded by showing that their exploratory outcomes considerably closer to the Canadian standards esteems thought about to that of the qualities acquired by JSCE code. They have also examined about different elements impacting the shear in FRP RC members as mentioned in the ACI-ASCE

Committee 445 (1998) which is utilized for conventional steel strengthened concrete members. As indicated by ACI-ASCE Committee 445, in a steel strengthened concrete member consequent to the formation of diagonal tension breaks, a member opposes the shear by methods for various components:

1) The shear opposition of uncracked concrete compression zone
2) Aggregate interlock
3) Arching action
4) The dowel action of the longitudinal reinforcement
5) Residual tractable stresses crosswise over breaks
6) The shear conveyed by the shear reinforcement.

Further, they have expressed that the shear contribution of the uncracked concrete relies upon the profundity of the uncracked zone and the concrete quality. They have additionally mentioned the significance of the unpleasantness of the split's inward surface, which relies upon the most extreme total size and on the split opening size both of which have an impact over the total interlock opposition.

D. Dowel Action in FRP RC Deep Beams

Effortlessness et al (1998) made a broad investigation on straightforward and continuous FRP fortified concrete beams. Seven basically supported beams and seven continuous T-section beams with various combinations of reinforcements and stirrups were tried. The materials utilized as reinforcements were steel, CFRP and GFRP. Under this investigation with various combinations of fundamental reinforcement and stirrups, the heap shared by the individual strengthening materials was assessed. They recognized the significance of the dowel impact in keeping the beam from a sudden fall because of shear disappointment. They also demonstrated that the dowel impact was low if there should be an occurrence of FRP bars when contrasted with steel bars. They additionally watched that among the FRP bars, GFRP bars had the most reduced dowel impact and CFRP bars were marginally better in producing up the dowel results. They concluded the work by showing that the utilization of GFRP stirrups expanded the shear deformation and deflection and diminished the pliability of the beam. Also, they called attention to that the sort of shear disappointment mode happened at the point when GFRP stirrups were utilized with FRP principle reinforcement in the event of normal essentially supported beams. The dowel impact was particularly basic in instance of continuous beams with FRP reinforcement.

Tottori and Wakui (1993) did some trial tests on FRP fortified members and concluded that the dowel limit of FRP reinforcement members was not as much as that of steel fortified members by around 70%. They also surmised that when FRP was utilized as flexural reinforcement, the dowel contribution was little and could be disregarded. The low dowel quality of FRP bars was because of FRP's low transverse firmness and quality.

Tim Stratford and Chris Burgoyne (2003) have done broad diagnostic model investigations on shear examination of concrete strengthened with FRP reinforcement to understand how the similarity, harmony and the material constitutive laws can be joined to build up the real conditions inside a FRP-fortified beam subjected to shear. This examination researches the similarity of FRP fortified concrete members being demonstrated utilizing with the lower bound hypothesis. The significance of this examination is to accentuation the reality that the lower bound hypothesis relies upon stress redistribution which isn't conceivable if there should arise an occurrence of FRP strengthened concrete members. As for the dowel action they have expressed that the heap conveyed by the dowel action of the reinforcement over a split is immaterial in steel fortified beams which have also been demonstrated by Kotsovos and Pavlovic (1999). In any case, with FRP reinforcement which has low transverse solidness, a substantially littler load will be conveyed by the dowel action as expressed by Kanematsu et al (1993) in their work. Consequently, this dowel action causes longitudinal splitting of the concrete along the flexural reinforcement as distinguished by Kotsovos and Pavlovic (1999) and also Sakai et al (1999). In this examination, models were created to clarify the dowel part which causes a sudden increment in the un-bonded length of reinforcement prompting uneven break propagation into the compression-zone, causing the beam to come up short. The impact of dowel burst because of the dowel action is considered as a vital method of disappointment in beams has been talked about in their examination which portrays the break of reinforcement under joined shear and pliable actions. Their prediction on FRP being utilized as beams principle ductile reinforcement which has low transverse quality, delineates the powerlessness of FRP to dowel break which does not happen with steel reinforcement as mentioned in Naaman and Park (1997), Bank and Ozel (1999). Maruyama et al (1989) made some examination concentrates to understand the impact of slanted shear breaks in FRP strengthened concrete beams by conducting tries different things with FRP stirrups being put slanted to the falsely made vertical split in concrete example. The investigations were performed utilizing concrete square examples in which the FRP stirrups were installed and elastic powers being connected over a counterfeit vertical split which was intentionally shaped at different points to cut over the FRP stirrups. CFRP, AFRP and GFRP bars made of Epoxy sap framework were utilized as a part of these examinations having distances across between 5 to 6 mm. A critical finding made in this work was that when FRP bars were subjected to tension by setting them at a point to the connected load the malleable limit of FRP bars diminished radically. If there should arise an occurrence of GFRP bars, when the strands were slanted at 30° to the horizontal, the diagonal elasticity was seen to be only 65% of the quality of the bar when the filaments were arranged horizontally. From the examination it was concluded that the most extreme pliable limit of FRP bars can be accomplished only when the filaments in the FRP bars are set opposite to the anticipated break in concrete. At the end of the day, the dowel powers are most extreme when the strands in the bars are opposite to the breaks.

II. COMMENTS ON LITERATURE REVIEWED

1) By including the vertical and/or slanted stirrups the slanted splits formation can't be modified. Such an addition also has next to no impact on a definitive quality.
2) By giving more vertical stirrups deflections at a definitive stack was observed to be lessened.
3) A higher stacking limit was seen beyond slanted splitting for beams with little shear traverse to-profundity proportions without shear reinforcement.
4) With little 'shear traverse to-profundity' proportion, transverse reinforcement has no impact on beam's quality. This was framed because of the philosophy that a single direct swagger shaped between the stacking point and the bolster reaction in which the transverse support was expected to have no part in changing the beam's quality. By the by, they have expressed that an expansion in the transverse reinforcement can decrease split widths.
5) For beams with more noteworthy profundity, the horizontal web reinforcement was observed to be extremely powerful in keeping the more extreme breaks.
6) The vertical web reinforcement are more compelling when the beam builds up a diagonal splits which are moderately level closer to the horizontal pivot.
7) This tied-curve action makes up for the lessened total interlock.
8) Finally, contrasting their test outcomes and different code provisions they concluded that the CIRIA (1977) technique was the most exact in foreseeing a definitive shear limit among the techniques considered. For deep beams with higher concrete qualities, the ACI Code predictions were conservative, in any case, if there should be an occurrence of the Canadian Code the predictions were found to give unconservative outcomes.

REFERENCES

[1] Yang, K. H., Eun, H.C. and Chung, H. S., The influence of web openings on the structural behavior of reinforced high – strength concrete deep beams, Engineering structures, in press,Enem, J.I., Ezeh, J.C., Mbagiorgu, M.S.W., Onwuka, D.O.Int. Journal of Applied Sciences and Engineering Research, Vol. 1, No. 2, 2012355Heinemann, U. K.
[2] Analysis of deep beam using Finite Element Method
[3] Quanfeny, W., Hoogenboom, P. C. J. (2004). Nonlinear Analysis of Reinforced Concrete
[4] Continuous Deep Beams using stringer – Panel Model. Asian Journal of Civil Engineering (Building and Housing). 5(1-2), 25.
[5] 8. Samir, M. O. H. D. and Chris, T. M. (2005). Nonlinear Finite Element Analysis of ReinforcedConcrete Deep Beams. Department of Engineering, University of Cambridge, Cambridge, CB2IPZ, England.
[6] Klus–Jurgen, B. (1990). Finite Element Procedures in Engineering Analysis.
[7] Khalaf, I. M. (2007). Prediction of Behaviour of Reinforced Concrete Deep Beams with WebOpenings Using Finite Elements. Civil Engineering Department, University of Mosul.
[8] Zienkiewicz, O. C. and Taylor, R. L. (2000). The finite element method, Butterworth
[9] American Concrete Institute, “Building Code Requirements for Reinforced Concrete”, Detroit, ACI-381-02.
[10] Chen, W.F., (1982), “Plasticity in Rinforced Concrete”, McGraw-Hill, Inc, New York.
[11] Cook, R.D., (1974), “Concept and Application of Finite Element Analysis”, John Wiley andSons, Inc., New York.
[12] El-Hashimy. H., Naser. M., and Farahat. A., (1990), “Cracking Load of Reinforced Concrete Deep Beams with Openings”, Convention paper.
[13] Khalaf, I.M., (1986), “Nonlinear Finite Elements Analysis of Reinforced Concrete Deep Beam”, M.Sc. Thesis, University of Mosul.
[14] Moaveni, S., (1999), “Finite Element Analysis Theory and Application with ANSYS”, Prentice-Hall, Inc., New Jersey.
[15] Ramakrishan, V ., and Anathanarayana, Y ., (1968), “Ultimate Strength of Deep Beams in Shear”, Journal of ACI, Vol. 65, pp. 87-98.
[16] 1Sanad, A., and Saka, M.B., (2001), “Prediction of Ultimate Shear Strength of ReinforcedConcrete Deep Beams using Neural Networks”, Journal of Structural Engineering, ASCE, Vol. 127, No. 7, July, pp. 818-828.
[17] Winter, G., and Nilson, A.H., (1978), “Design of Concrete Structures”, 9th Edition.
[18] Strength and behavior of deep beams in shear By-Ha Rawdon de Paiva & Chester P. Siess
[19] In Karl W. Linsenmann (ed.), Proceedings. St. Louis, Lutheran Academy for Scholarship (1965)
[20] Experimental wall beam model (LEONHARDT; WALTHER, 1966)
[21] Prediction of ultimate shear strength of reinforcedconcrete deep beams using neural networks by A. Sanad1 and M. P. Saka,2 Member, ASCE
[22] Reinforced Concrete Deep Beams – by F K Kong
[23] Shear strength of deep beams By: K.N. Smith and A.S. Vantsiotis
[24] shear strength characteristics of reinforced concrete (rc) beams Lehwalter (1988)