The role of shear span to effective depth ratio (a/d) on the deflection in deep and normal reinforced concrete beams when this ratio is (1, 2, 3, and 4)

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Abstract. This research presents an experimental study to investigate the role of shear span-to-depth (a/d) ratio for the cross-sectional area of reinforced concrete beam on the deflection in reinforced concrete beams (deep and normal beams), when the value of shear span-to-depth ratio (a/d) equal to (1, 2, 3, and 4) respectively, the behavior of deep beams is significantly different from that of normal beams. Because of their proportions, deep beams are likely to have strength controlled by shear. The a/d ratio is to have a very significant role on the deflection where the values of a/d ≤ 2 (deep beam) and the value of a/d > 2 (normal beam) according to (ACI 318-08) with the constant reinforcement ratio ρ. The experimental program included casting and testing four beams with a constant width of cross section (b = 250 mm) and reinforcement ratio ρ. Also, all models of beams tested under two-point loads. The results showed that the percentage of average increasing in value of deflection in normal beam (a/d > 2) 1.68 % from value of deflection in deep beam (a/d ≤ 2). Also, the gained deflection due to load in ranges from (10 to 110 kN) increase by (31.64 %) when a/d > 2 in TB1. moreover, the deflection due to load in ranges from (10 to 190 kN) increase by (21.28 %) when a/d < 2 in TB2. Furthermore, the gained deflection due to load in ranges from (10 to 360 kN) increase by (21.21 %) when a/d < 2 in TB3. as well as, in this research studied the role of shear span-to-effective depth ratio (a/d) on the crack width and the number of cracks.

Keywords: Deep beam, normal beam, shear span, two-point loads, crack width, deflection, strength, deformation in compression zone.

1 Introduction
A reinforced concrete member in which the total span or shear span is exceptionally small in relation to its depth is called a deep beam. Some examples of deep beams include bridge bent caps, transfer girders, and pile caps. Historically, reinforced concrete deep beams were designed with empirical methods or simple approximations [1-3].

Evaluating the role of shear span-to-depth ratio on the deflection for reinforced concrete beams (deep and normal) has been a great challenge because of the complexity of these structural members. Design specifications, such as the Bridge Design Specifications of the American Association of State and Highway Transportation Officials (AASHTO LRFD, 2008) and the Building Code Requirements for Structural Concrete of the American Concrete Institute (ACI 318-08). In AASHTO LRFD 2008 and ACI 318-08, beams or components are considered deep when the shear-span-to-depth ratio (a/d) is less than or equal to 2 and normal beams a/d > 2 [4]. It has been also recognized that, as members become deeper, the ultimate shear strength Vult becomes progressively larger than that in slender beams. In the last five decades, experimental and theoretical studies were performed. Clark [5] reported that the nominal shear strength of an RC beam is a function of the compressive strength of concrete, the longitudinal reinforcement ratio (ρ) and a/d. Leonhardt and Walther [6] investigated the size effect in RC members with a/d ranging from 3 to 8 subjected to shear. Comparisons between short
and slender members were made. Kani [7] studied the size effect on the shear strength of RC beams with a/d ranging from 1 to 8 without stirrups. Test results indicated significant influence of a/d on the deflection in RC beams. These studies included the influence of a/d on deflection behavior of RC beams. In the classical theory of RC; shear failure modes for increasing a/d0 are classified into; deep beam failure, shear compression failure, shear tension failure, flexural shear failure [8]. There are some researches, which has been applied various types of loading, web and longitudinal reinforcement to concrete deep beams to present both effect of web and longitudinal bars in failure load and comparison with gained experimental results. Recording of deflection at two points along the deep beam and normal length, tensile bars strains and the strain at the concrete surface with simply supported high-strength self-compacting concrete (SCC) deep beams in the laboratory is performed [9]. The effect of a/d on the deflection and load transfer mechanism observed for the laboratory results is presented [10].

It is well known that deep beams behave very differently from normal beams as arch action rather than flexure dominates the behavior, after diagonal cracking has occurred [11]. An experimental program is carried out to investigate the possible causes of size effect; an evaluation was conducted of the behavior and the effect of shear span-to-effective depth ratio (a/d) for reinforced concrete beams based on results from the test of four beam specimens [12].

2 Materials and methods

2.1 Strain gauges installation

Strain gauges were divided according to manufacture purpose in two types:

1. Concrete strain gauges, which exactly use to measure the strain in compression zone (Figure 1).

   These gauges were installed externally on the surface of concrete beams at the mid-span position on the top surface of the Reinforced concrete beam using a tape meter to ensure accurate measurement by using a cyanoacrylate adhesive for TML strain gauges [13], which manufactured in Tokyo Sokki Kenkyujo company, after cleaning and smoothing the top layer of concrete beams in compression area.

![Figure 1. Design of test specimens.](image-url)
2. Rebar strain gauges, which exactly use to measure the strain in compression and tension zone (Figure 1), these gauges were glued directly on the surface of Bars by using the same adhesive mentioned above, which manufactured in Tokyo Sokki Kenkyujo Company. However, such a simplistic approach has a significant drawback due to a significant reduction of the effective bond area, thus making the results of bond stress analysis unreliable [14]. After cleaning and smoothing the top layer of reinforcement bars in specified area to calculate strain in bars. The aim is to create a surface without pores, notches and oxides, not too rough and easily wetted [15]. Furthermore, rebar strain gauges were protected against changing in temperature and humidity before and while testing, by using hermetically sealed encapsulation [16] as wrapping it using some plastic tapes to protect gauges from internal and external circumstances.

2.2 Shear design methods for reinforced-concrete beams
The Four standard concrete cylinders models with dimensions (150×300 mm) with mix design proportion (Group A2) shown in Table 4, have tested under a universal hydraulic machine to determine:
1. Modulus of elasticity of concrete.
2. The splitting tensile strength of concrete ($f_{sp}$).

Also, three cubes (150×150×150 mm) have tested to determine the compressive strength of concrete at 28 days which used in casting all tests beams. The design is based on flexural failure through made the reinforcement ratio ($\rho$) is constant for all specimens. the design is made by Ultimate stress method (USM) according to ACI-code through determine the RC beam dimensions and applying two-points load on specimens, distributed according the shear span length (a) of tests beams [17].

2.3 Constituent materials and properties
General description and specification of Constituent materials which used in this study are listed below:

**Cement.** Ordinary Portland cement produced at northern cement factory (Tasluja-Bazian) is used throughout this investigation. The cement is stored in air tight plastic containers to avoid the harmful effects of humidity. Analysis of chemical composition and physical properties of this cement are made at the Tasluja-Bazian company. Cement conforms to the Iraqi specification No. 5/1984 [18].

**Fine Aggregate.** Al-Ukhaider natural sand is used. The grading of the fine aggregate is shown in Table (1), which complies with the Iraqi Standard Specification No.45/1984 [19].

| No. | Sieve (mm) | Fine aggregate % | % Passing | IQS 45:1984 Zone (2) |
|-----|------------|------------------|-----------|---------------------|
| 1   | 5          | 100              | 90-100    |                     |
| 2   | 2.36       | 85.75            | 75-100    |                     |
| 3   | 1.18       | 63.84            | 55-90     |                     |
| 4   | 0.6        | 37.92            | 35-59     |                     |
| 5   | 0.3        | 12.32            | 8-30      |                     |
| 6   | 0.15       | 1.21             | 0-10      |                     |

**Coarse Aggregate.** Crushed gravels from Al-Mansoria area are used in this study. The grading of the coarse aggregate is shown in Table 2, which complies with the Iraqi Standard Specification No. 45/1984.

| No. | Sieve (mm) | Coarse aggregate % | % Passing | IQS 45:1984 size (5-14) mm |
|-----|------------|---------------------|-----------|---------------------------|
|     |            |                     |           |                           |
Steel Reinforcement. All the beams are longitudinally reinforced by two bars of 12 mm diameter of 492 MPa yield stress as flexural reinforcement without shear reinforcement so that failure would occur by diagonal tension to evaluate the shear strength of concrete of these beams. The test results of the bars (ϕ12mm) satisfy ASTM A615 requirements [20].

Super plasticizer (G51). For the production of self-compacting concrete (SCC), super plasticizer (high range water reducing agent HRWRA) based on poly carboxylic ether is used. One of a new generation of polymer-based super plasticizer, designed for the production of Self-compacting concrete Glenium 51 is used; the normal dosage for Glenium 51 is (0.5-0.8) L/100 kg) of cement. Dosages outside this range are permissible subjects to trial mixes. Glenium 51 [21] has been primarily developed for the applications in the ready mixed concrete industries where the highest durability and performance are required. The typical properties, shown in Table 3, are added to achieve flow ability.

### Table 3. Typical properties of Glenium 51[21].

| No. | Main action          | Concrete super plasticizer |
|-----|----------------------|----------------------------|
| 1   | Color                | Light brown                |
| 2   | pH. Value            | 6.6                        |
| 3   | Form                 | Viscous liquid             |
| 4   | Subsidiary effect    | Hardening                  |
| 5   | Relative density     | 1.1 at 20 °C               |
| 6   | Viscosity            | 128 ± 30 cps at 20 °C      |
| 7   | Transport            | Not classified as dangerous|
| 8   | Labeling             | No hazard label required   |

Glenium 51 is free from chlorides; it is compatible with all Portland cements that meet recognized international standards. Trial mixtures using varying amounts of admixture should determine the optimum dosage of an admixture.

Mix Design for Self-compacting Concrete (SSC). Many mix proportions were tried to get the target strengths of SCC [22]. From each type of concrete, two mixes (Group A, Group A2) were considered to get the concrete of normal compressive strength at 28 days of about 28MPa and high compressive strength at 28 days of about 30 MPa. SCC mixes were designed according to the European Guidelines for Self-Compacting Concrete (EFNARC) [23], the ingredients and their quantities per cubic meter for each mix of SCC and are listed in Table 4.

### Table 4. Mix design of SCC mixes by weight.

| Group | Mix notation | W/C ratio | Cement | Lsp | Total powder | Sand | Gravel | Water | Glenium 51 |
|-------|--------------|-----------|--------|-----|--------------|------|--------|-------|------------|
| A1    |              | 0.8       | 250    | 277 | 527          | 725  | 833    | 200   | 5.3        |
| A2    |              | 0.55      | 346    | 204 | 550          | 743  | 833    | 190   | 6.6        |
| A3    |              | 0.38      | 474    | 105 | 579.3        | 758.4| 833    | 180   | 8.10       |
| A4    |              | 0.33      | 515.2  | 82  | 597.2        | 773.1| 833    | 170   | 14.9       |
Table 5. Mix proportions of SCC by weight.

| Mix notation | Total powder (Cement+Lsp) | Sand | Gravel |
|--------------|---------------------------|------|--------|
| A1           | (0.47+0.53)               | 1.38 | 1.58   |
| A2           | (0.63+0.37)               | 1.35 | 1.51   |
| A3           | (0.82+0.18)               | 1.31 | 1.44   |
| A4           | (0.86+0.14)               | 1.29 | 1.40   |
| A5           | (0.89+0.11)               | 1.36 | 1.39   |

2.4 Preparing the specimens for testing

**Specimens paint.** All tests beams were painted with white color shown in Figure 2. the purpose of painting models to see clearly cracks paths throughout the loading and make us to fixed the value of load with cracks in front side of test beam which installed to test.

![Figure 2. Painting all specimens with white color.](image)

**Planning the specimens.** The planning contains division one of sample's faces to many squire by (5×5 cm), to making easy the process of testing and determine a path and width of cracks as shown in Figure 3.

![Figure 3. Planning the specimen’s face.](image)

**Loading system and instrumentation.** The Loading system and instrumentation can be summarized by the following steps:

1. The beams were lifted from the curing water tank at the age of 28 days after casting, left to dry, and then painted with white color so that cracks can be easily.

2. Detected. The beams were tested under two-point loading using a universal hydraulic machine of 2000 kN capacity available in the Structural Engineering Laboratory, College of Engineering, Diyala University as shown in Figure 4. The beam specimens were tested as simply supported using rigid supports with 1000 mm clear span in TB1, TB2 and TB3, and 1800 mm clear span in R.B. also,
loading distance variable to support, in order to provide a shear span to effective depth ratio (a/d) equal to 1, 2, and 4. The loads were applied in successive increments up to failure. A dial gauge of 0.001 mm accuracy was attached firmly at the center of the bottom face of the beam to record mid span deflection. The load that produced the diagonal crack and the ultimate shear strength were recorded. Crack patterns were marked on the beams.

Figure 4. Beam testing setup.

3. Arrange data, classification data according the aim of this research paper as Tables contain significant data which used in to make charts and appropriate conclusions.

3. Results
3.1 Failure modes and crack patterns
From Table 6 the tested beams (TB2, TB3) were classified as a deep beams according ACI-318-08 show low values in ultimate deflection (14.2, 12.4 mm) respectively. Also, while the variation in shear span-to-effective depth ratio (a/d) from 1 to 4 in tested beams (TB3, TB1) with increasing load in 360 to 118 kN, were noted the decreasing percentage of deflection in 55 %. Furthermore, were noted in results in Table 6, the normal beams (TB1, R.B.) which have shear span-to-effective depth ratio (a/d) > 2 had been high value of deflection as compared with (TB2, TB3). The specimens exhibited two different modes of failure. The beams with shear span-to-effective depth ratio (a/d) 4,2 in TB1, TB2 respectively failed in flexural mode, whereas the specimens with shear span-to-effective depth ratio (a/d) 1, 3 in TB3, R.B. respectively failed in diagonal splitting failure pattern mode.

Table 6. Summary of experimental program.

| Speci. Name | L (mm) | a (mm) | a/d | d (mm) | As (mm²) | No. of bars | fctest (MPa) | Shear Design | Pexp. (kN) | Pfai. (kN) | Δulti (mm) | vcr | vulti |
|-------------|--------|--------|-----|--------|---------|-------------|-------------|-------------|------------|------------|------------|-----|-------|
| Series 1: Reference beam. |        |        |     |        |         |             |             |             |            |            |            |     |       |
| R.B.        | 2000   | 900    | 3   | 300    | 565     | 5ø12       | 25          | Ø10@8Ømm c/c | 150        | 110        | 49         | 51  | 57    |
| Series 2: Constant (b) Varying (a/d) ratio. |        |        |     |        |         |             |             |             |            |            |            |     |       |
| TB-1        | 1200   | 500    | 4   | 125    | 565     | 5ø12       | 25          | Ø10@8Ømm c/c | 150        | 118        | 22,2       | 76  | 48    |
| TB-2        | 1200   | 500    | 2   | 250    | 565     | 5ø12       | 25          | Ø10@8Ømm c/c | 150        | 250        | 14,2       | 41  | 95    |
| TB-3        | 1200   | 300    | 1   | 300    | 565     | 5ø12       | 25          | Ø10@8Ømm c/c | 150        | 360        | 12,4       | 105 | 175   |

*(b) Is Constant = 250 mm for all series.
*(ρ) Is Constant for all series.

The cracking shear force Vcr, was assumed as the force that caused the first diagonal cracking. The ultimate shear force Vulti, was taken as half the failure load read from the testing machine. In the
beams, as the first, shear cracks formed within the mid-span. When the load reached \((P_1 = 76, P_2 = 41, P_3 = 105, P \text{ (R.B.)} = 51 \text{ kN})\) in \((\text{TB1, TB2, TB3, R.B.})\) respectively, Figure 5 show the shear stress caused the failure in specimens beams which mentioned above and caused appearance of diagonal cracks. The shear transfer run along one major diagonal crack, which developed from the flexural crack at one side or two sides of the beam in the mid-span of the support zone when the load was close to the maximum. Also the bond failure between steel bars and concrete was observed in the form of the horizontal crack following the longitudinal reinforcement in diagonal splitting failure pattern at supports exactly in TB3 and R.B.

![Figure 5. Crack pattern at failure of SCC beams with different values of \((a/d)\).](image)

### 3.2 Load deflection curves with different values of \((a/d)\)
Table 7 show the value of deflection with shear span to depth \((a/d)\) ratio, where: \((a/d)\) for \(\text{TB-1, TB-2, TB-3, R.B. (4, 2, 1, 3)}\) respectively. Figure 6 explain the behavior of all test beams and the significant role of shear span-to-effective depth ratio \((a/d)\) in deflection under different values of two-points load through the curves of deflection were noted the a little bit different in amount of deflection for all specimens in range of shear span-to-effective depth ratio \(1 \geq a/d \leq 2\) which were as linear relation exactly in TB2 and TB3 which classified as a deep beams according to ACI-318-08, whereas in range of \(a/d > 2\) we can see the big different in values of deflection between all tested beams. where the TB1 and TB3 (deep beams) shows the most lower values in deflection in this range as compared with the TB1 and R.B. which is classified as a normal beams according ACI-318-08.

**Table 7.** The results of deflection under the load with different values of shear span-to-effective depth ratio \((a/d)\).

| Specimen Name | Load (kN) | Deflection (mm) |
|---------------|-----------|-----------------|
| TB1           | 10        | 31 50 71 96     | 110 0.68 2.82 5.2 7.8 11.1 22.2 |
| TB2           | 10        | 50 90 140 170   | 190 0.64 3.18 4.94 7.7 9.3 14.26 |
| TB3           | 10        | 90 190 290 320  | 360 0.56 3.88 6.02 9.44 10.46 12.44 |
| R.B.          | 10        | 31 51 66 90     | 110 0.76 2.2 4.8 7.1 19.2 49 |
3.3 Effect of load on the deflection in deep and normal RC beams

Figure 7 reveal that the behavior of deep reinforced concrete beams (TB2 and TB3) under two-point loads completely different as compared with the normal reinforced concrete beams (TB1 and R.B.), where the load-deflection curves show the linear relation with the progress of load, this meant the deflection in deep beams proportional with load until the load failure. Whereas, the load-deflection curve consist of two parts for the normal beams. the first part is linear with constant slope until formation the first shear cracks in the tension zone, the second began after the first crack with a slope less steep than that of the first part due to increase and enlargement the flexural cracks and formation shear cracks.
3.4 Effect of shear span-to-effective depth ratio (a/d) on the Crack width and Number of cracks

Table 8 and Figure 8 show the values of \( V_{cr} \), \( V_{ult} \). For all test specimens and values of crack width in (mm), were noted the construction behavior of all test specimens under two-point loads and with different ratio of shear span-to-depth (a/d). Where the TB2 and TB3 (deep beams) have the minimum initial crack width with the heigh initial crack shear force. Furthermore, we can see the proportionally effect of shear span-to-effective depth ratio on the crack width. Where, in the ratio of a/d ≤ 2 (deep beams) noted minimum values of crack width. Whereas, in ratio of a/d > 2 (normal beams) in TB1 and R.B. recorded a heigh values of crack width. In this paper we can predict by the significant role of shear span-to-effective depth ratio a/d on the crack width. Also, the role of \( V_{ult}/V_{cr} \) Ratio on the crack width. Where, when the ratio of \( V_{ult}/V_{cr} \) Equal 1.7, 2.9 in TB3 and TB2 respectively the minimum values of crack width seen in the results in table 7. Moreover, were founded the heigh amounts in crack width when the ratio of \( V_{ult}/V_{cr} \) ≤ 1.4 in TB1 and R.B. (normal beams). The cracking shear force \( V_{cr} \), was assumed as the force that caused the first diagonal cracking. The ultimate shear force \( V_{ult} \), was taken as half the failure load read from the testing machine.

| Specimen Name | Load (kN) | Crack width (mm) | No. of Cracks |
|---------------|-----------|-------------------|---------------|
| TB1           | 76        | 85 91 100 110 115 | 0.2 0.26 0.78 1.1 1.9 | 2.6 9 |
| TB2           | 41        | 75 105 150 200 240 | 0.04 0.1 0.15 0.2 0.3 | 0.4 5 |
| TB3           | 105       | 200 250 300 330 360 | 0.04 0.1 0.2 0.24 0.3 | 0.34 6 |
| R.B.          | 51        | 56 60 80 96 110    | 0.08 0.1 0.2 0.8 3   | 3.9 10 |

As for the number of cracks, the tested beams exhibited the similar behavior as compared with there behavior in crack width, were founded the low number of cracks with the shear span-to-effective depth ratio a/d ≤ 2 in TB2 and TB3 (deep beams). Whereas noted the heigh number of cracks with the ratio of a/d > 2 in TB1 and R.B. as shows in Table 8 above and Figure 9.

![Figure 8. Effect of shear span-to-effective depth ratio (a/d) on the crack width.](image-url)
Figure 9. Effect of shear span-to-effective depth ratio (a/d) on the number of cracks.

3.5 Load – Strain in compression and tension zone

Table 9, Figure 10 and Figure 11 reveal that the shear failure and yield point for all test specimens took place in compression zone. Also, the TB2 and TB3 had approximately similar behavior in tension zone of strain at failure and yield points. Through, they have the minimum values of strain at initial load and at failure point as compared with other specimens (TB1 and R.B.). From other side, the TB1 and R.B. (normal beams) have the heigh primary values of strain associated with initial load in tension and compression zone. Also, its failure point took place at minimum values of load are 96, 115 and 96, 110 kN in compression and tension zone respectively. Whereas, failure occurred in tension zone with heigh value of load is 350 kN in TB3 (deep beam).

Table 9: Load-strain in compression and tension zone with different ratio of shear span-to-effective depth (a/d).

| Specimen Name | Load (kN) | Strain in compression zone (10^-6) | Strain in tension zone (10^-6) |
|---------------|-----------|-----------------------------------|-------------------------------|
| TB1           | 10 31 50 71 96 110 80 295 552 801 1957 3327 |
| TB2           | 10 50 90 140 170 190 17 95 298 735 988 5105 |
| TB3           | 10 90 190 290 320 350 6 71 212 447 501 555 |
| R.B.          | 10 31 51 66 90 96 16 108 350 1100 1834 2018 |
Figure 10. Role of shear span-to-effective depth ratio (a/d) on the strain in compression zone.

Furthermore, the strains in all test specimens increase linearly with the increase in loads in elastic zone, then the strains increase greatly when the main cracks formed with failures happened. However, for TB2 and TB3, the strains increase slowly with an increase in load at the elastic stage until reached the yield point as compared with TB1 and R.B., which the strain rapidly increase with an increase in load at the elastic stage until reached the yield point. then in the plastic zone in curves of load-strain shown in Figure 10 and 11 noted faster increase in strain for all test beams until reached the failure point.
4 Discussions

Depending on the results of the role of shear span-to-effective depth ratio (a/d) conducted throughout this study, the following conclusions can be made:

1. Shear span-to-effective depth ratio (a/d) have a fundamentally significant on the deflection in deep and normal reinforced concrete beams when variance at (2< a/d ≤ 2). where the percentage of increasing in deflection is 56.4 % for the TB1 and TB2, Also, this percentage equal 14.5 % in TB2 and TB3. whereas, the percentage of increasing in deflection for TB1 and R.B. equal 120%. this meant the deflection in normal beams (a/d > 2) twice the value of deflection in deep beams (a/d ≤ 2) with costant conditions.

2. The mode of failure and crack pattern in deep and normal reinforced concrete beams with constant reinforcement ratio (ρ) and beam width (b) fundamentally depends on ultimate shear force to shear crack force ratio (V_{ul}/V_c). We can describe how sudden the failure was by means of ratio V_{ul}/V_c. When it is greater and equal 1.0 as in R.B. we have a brittle diagonal splitting failure and with the increase of V_{ul}/V_c as in TB3 (1.6) we can observe a more steady damage process although were used the self compacting concrete (SCC) to made beams concrete.

3. Crack width and the number of cracks was influenced by shear span-to-effective depth ratio (a/d). Herein in this paper and its results were noted that the percentage of increasing in informed crack width in TB2 and TB3 is 9 % and 7.5 % repectively, furthermore the increasing percentage of number of cracks between the same tested beams is 20 %. Whereas, the percentage of increasing in crack width which took place in TB1 and R.B. is 12 % and 48 % respectively. Also, the percentage of increasing in number of cracks between the TB1 and TB2 is 80 %. Also, between the TB3 and R.B. is 66.7 %.

4. The effect of shear span-to-effective depth ratio (a/d) on the strain in copresison zone have more significant than tension zone. Because, the failure firstly occurred in compression zone according the data in Table 9 and Figure 8. Also, founded that the percentage of average increasing in strain in compression zone with average increasing percentage in load for TB2 and TB3 are 2.5, 2.8 % and 113, 196 % respectively,whereas, the percentage of average increasing in strain in compression zone with average increasing percentage in load for TB1 and R.B. is 1.22, 2.17 % and 72, 69 % respectively.

The percentage of average increasing of strain in tension zone with the average increasing percentage of load for TB2 and TB3 are 2.4, 3.62 % and 114, 197 %. Whereas, the percentage of average increasing in strain in tension zone with average increasing percentage in load for TB1 and R.B. are 1.98, 1.92 % and 69, 74 % respectively.

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