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New Numerical Study for Strengthening Slabs Behavior under Repeated Loads

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Abstract

The basic concept of using the finite element method of analysis in constructing analytical models for the study of behavior of reinforced concrete members is discussed. The finite elements method chosen to represent the concrete, the steel reinforcement, and the bond links between the concrete and steel reinforcement are described, modeling with a proper finite element program in idealization the considered structure is greatly needed. In this paper demonstrates that the behavior of reinforced concrete cracked slabs (350x80x20) were tested under fatigue loading with 3.3 Hz (200 r.p.m) and had the same cross section of dimensions and main longitudinal reinforcement distribution and cross sections for all slabs. These slabs had four deformed longitudinal steel with 10 mm diameter as main steel at depth 17.5 cm, the total length of each slab was 3.5 m and the span length was 3.0 m, the width was 80 cm, and the total depth was 20 cm. The slabs were loaded under fatigue loads in two point loads [2]. Many variables have been investigated in regard to stress and deformation. However, due to the complex nature of the phenomenon and due to great difficulties in measuring the relevant properties in the vicinity of a steel bar in concrete there is still a lack of know-how and the general applicability of results is still insufficient. It was thought worthwhile to treat repeated load in a nonlinear numerical analysis by taking into account cracking and larger local deformations. If the method of material modeling and numerical procedure should be successful, it would be possible to treat numerous external and internal variables only by varying the material properties. External variables could be loading rate and strengthening methods, whereas internal variables could be concrete composition, strength, bar surface, and dimensions. In all cases, the calculation would be the same, only the input parameters would be different. The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them.

In this study, a special smeared crack model is adopted. The constitutive matrix used in this analysis has been derived in detail by reference [5]. Within this model the initiation of a cracking process at any location happens when a principal stress component exceeds a prescribed tensile limit [1].

Keywords: repairing; gluing, CFRP, shotcrete, fibershotcrete.

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1-Introduction

An important characteristic of concrete is its cracking behavior at low tensile stresses. The cracking of concrete is a major factor contributing to the nonlinear behavior of reinforced concrete structures. Realistic theoretical analyses taken into consideration, the cracking in concrete even under service loads. The cracking in concrete structures have widely been modeled in finite element analyses and some fumes program like ABAQUS. As discussed in reference [3], the authors are of opinion that the steel strain εs is so far not yet considered in any other formulation.

2- Material response characteristics of the elements (CPE4)

In this study, we have used solid continuum elements 4- node blinear elements for concrete elements. These elements have two degree of freedom 1, 2 and four faces for plane stresses. The description of the interface element was adopted in ABAQUS program which developed by reference [6] and for steel truss elements were used, The Lagrange multiplier method is usual approach for contact constraints in this type of element. The friction forces acting on the contact area follow Coulomb's law.

3- Concrete

As the loading changes from uniaxial to triaxial stress states, a unified approach is advantageous when selecting a constitutive model for concrete. Such as model was proposed recently by Ottosen [4] and is adopted herein. The model is quite simple to work with, as it is based on nonlinear elasticity, in which the secant values of Young's modulus and Poisson's ratio are changed appropriately. This alternation is obtained through use of a nonlinearity index that relates the actual stress state to the failure surface. This model has a number of desirable features:-

-It includes the effect of all three stress invariants.

-Dilatation is considered.

-Completely smooth stress-strain curves are predicted.

-Realistic failure stresses are predicted.

-Different post-failure behavior can be easily simulated.

The model applies to all stress states including those where tensile stress occurs. In addition, calibration of the model requires only simple data. These data are obtained usually by standard uniaxial tests of the concrete in question. The construction of the model can be conveniently divided into steps:-

(1)- Failure and cracking criteria.

(2)- Nonlinearity index.

(3)- Change of the secant value of Young's modulus.

(4)- Change of the secant value of Poisson's ratio.

4- Results

4.1Slabs strengthening with Carbon Fibers

The stress and displacements curves for beams are shown in Fig. 1 to Fig 3. Fig 1 shows total displacements and other curves observed(u1)and (u2). Fig. 4 to 5 observed the stresses $\sigma 1$, $\sigma 2$ for slabs strengthening with Carbon Fibers. Fig. 6 the vertical displacement with time but Fig. 7 discusses support reaction Rft reflects the influence of external load with time for slabs strengthening with Carbon Fibers.

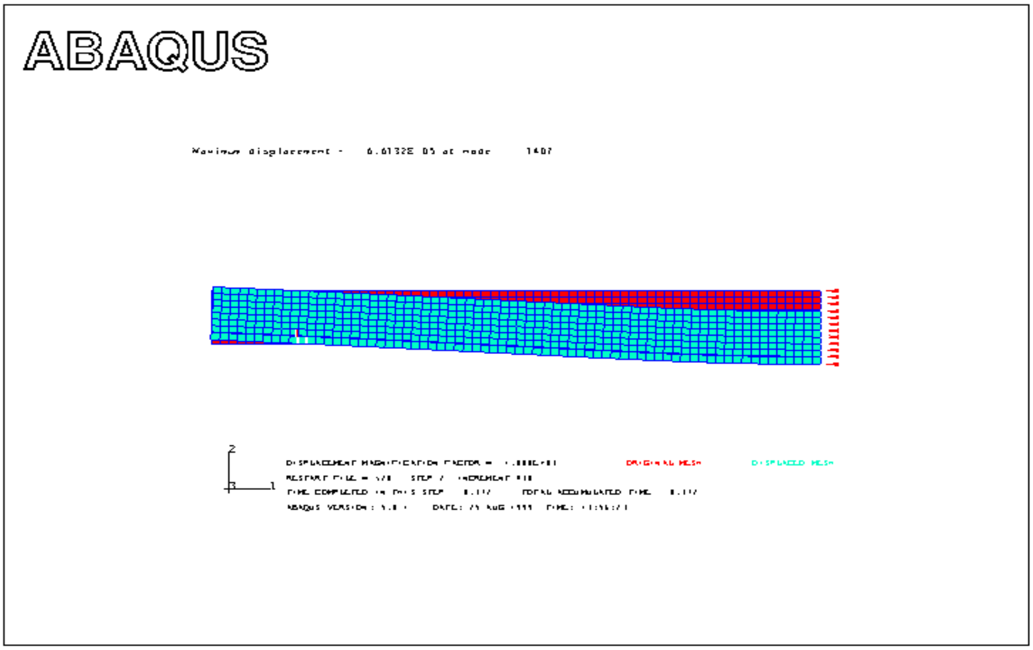

Fig. 1 The vertical displacement(u1) of the Slabs Strengthened with Carbon Fibers

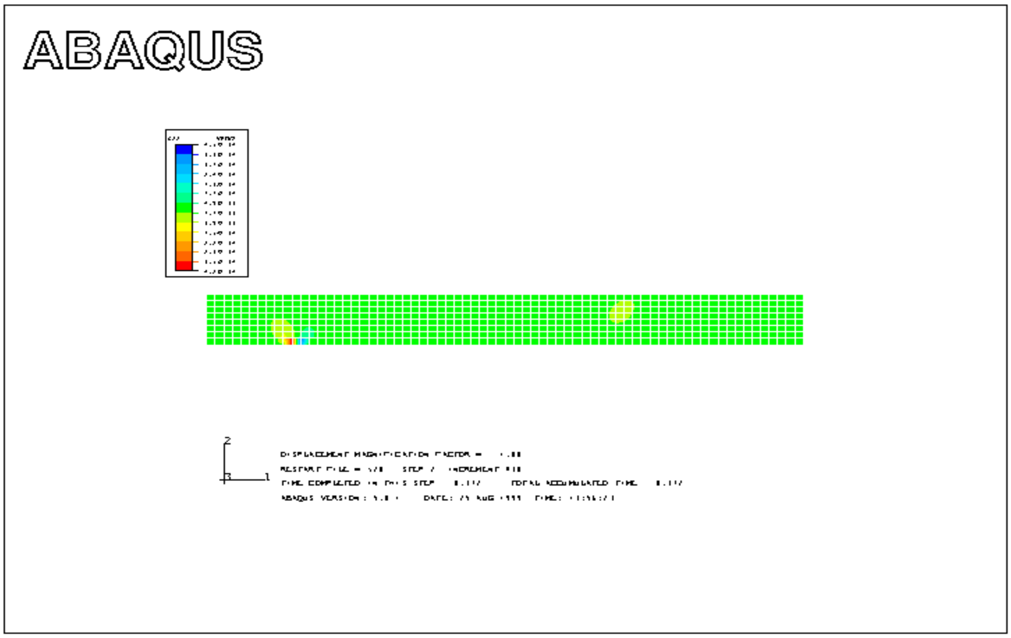

Fig.2 The vertical displacement (u1) of the strengthening slabs with Carbon Fibers

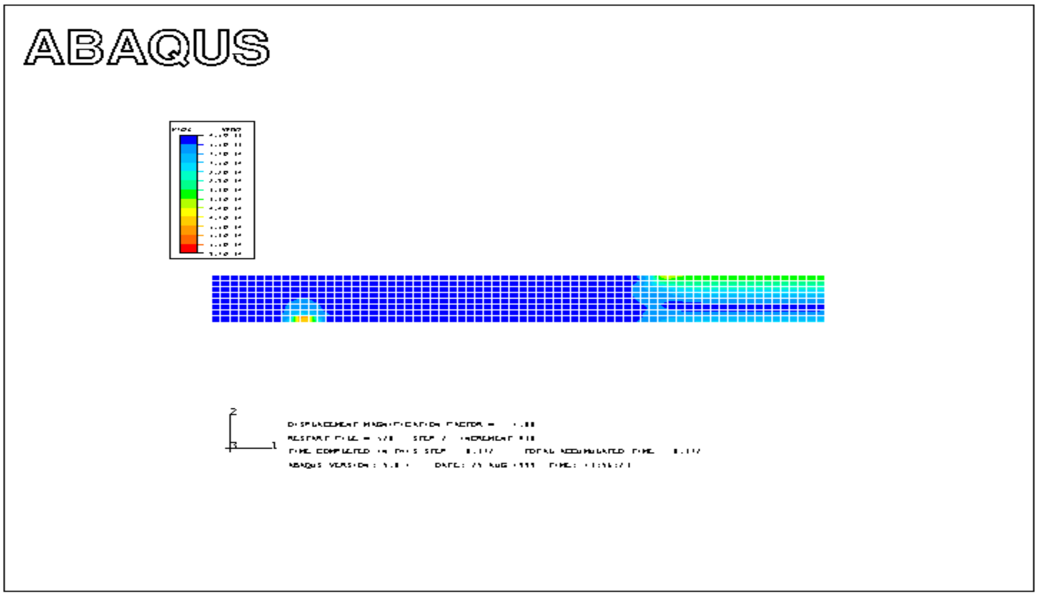

Fig.3 The horizontal displacement (u2) of the strengthening slabs with Carbon Fibers

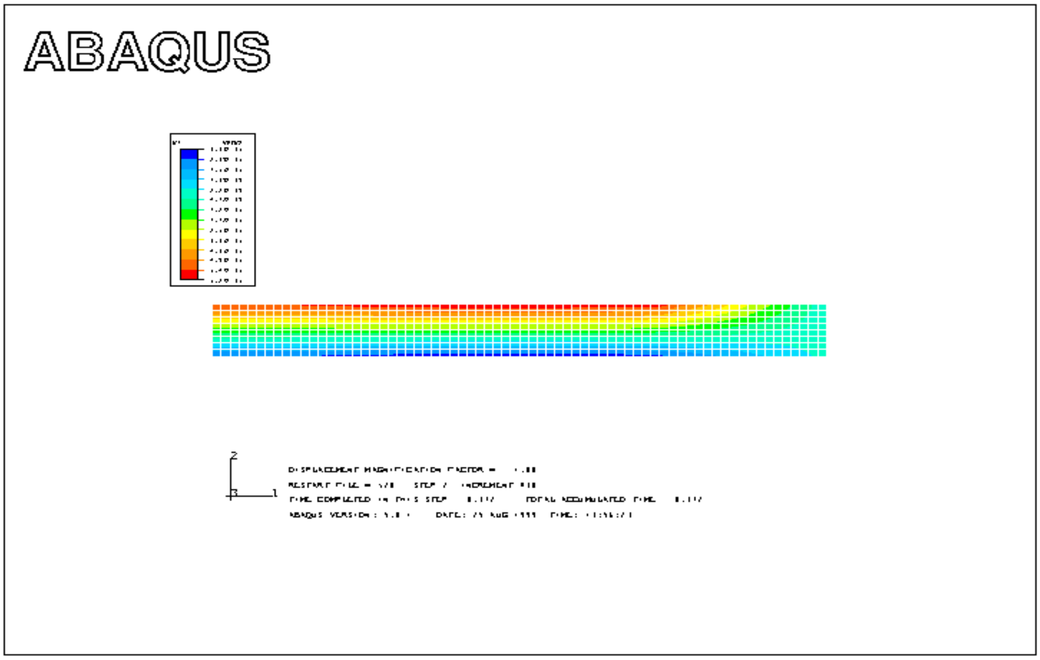

Fig.4 The horizontal stresses (σ1) of the strengthening slabs with Carbon Fibers

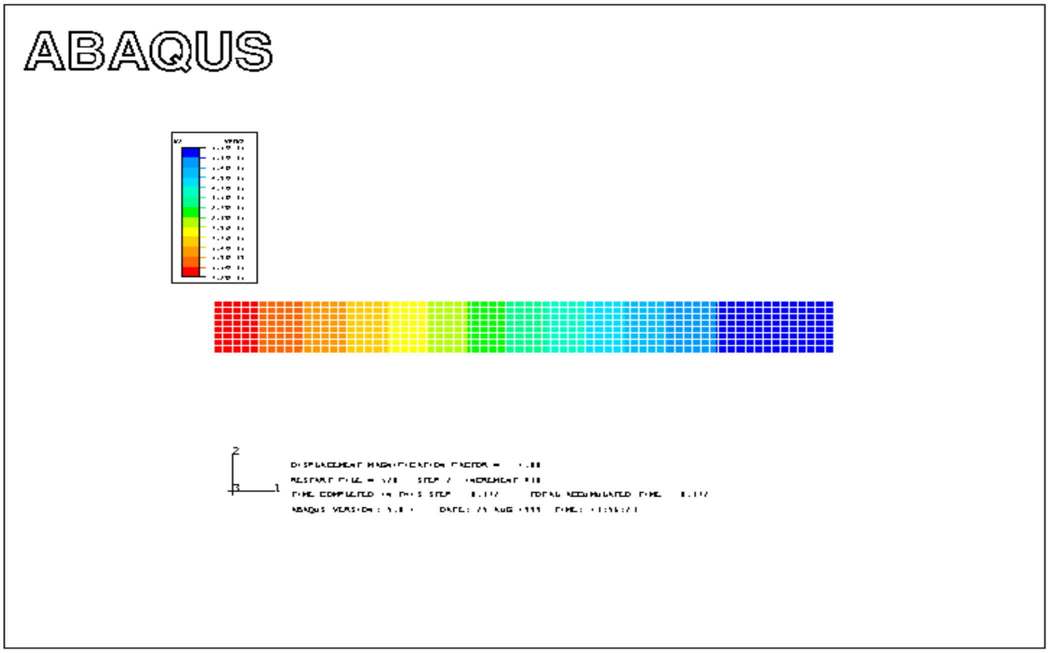

Fig.5 The vertical stresses (σ2) of the strengthening slabs with Carbon Fibers

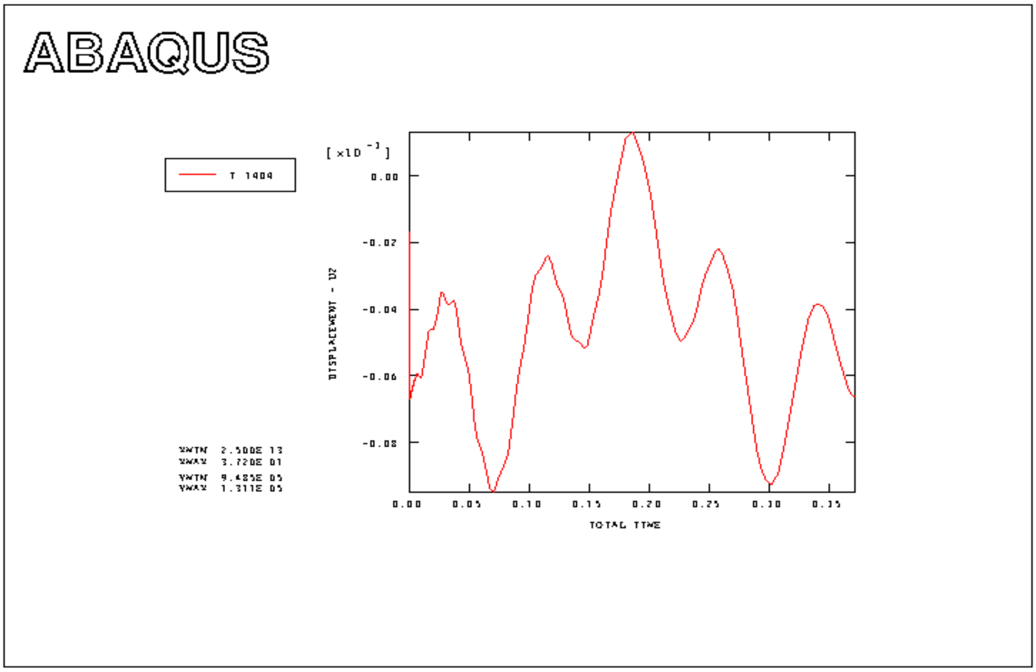

Fig.6 Vertical displacement and time (u2) of the strengthening slabs with Carbon Fibers

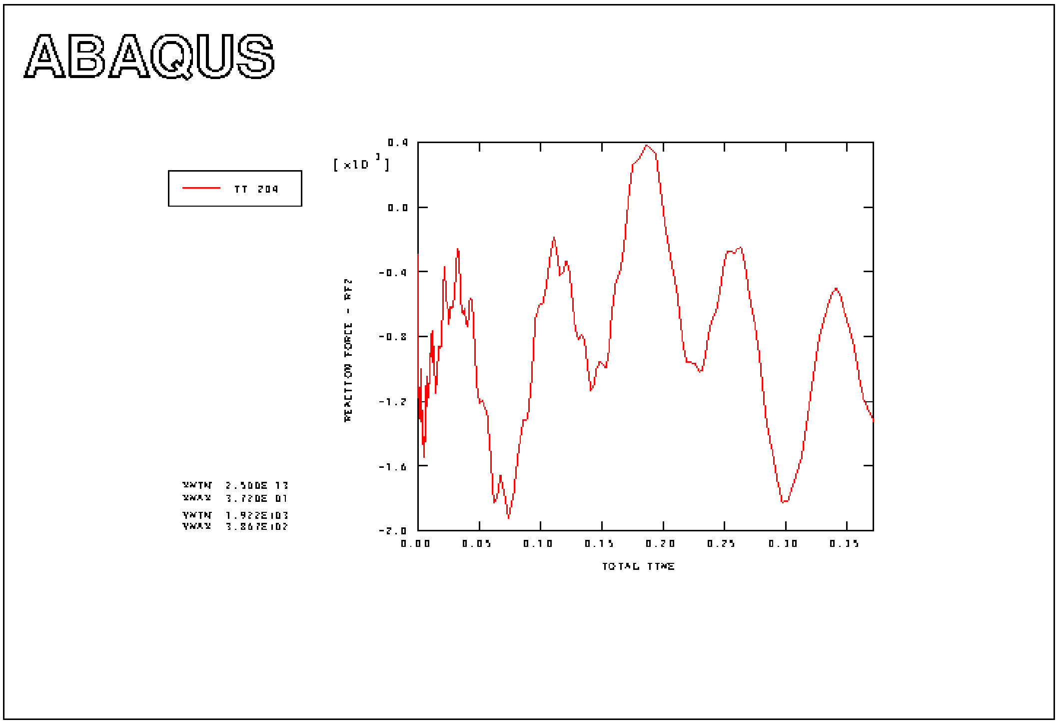

Fig.7 Vertical support reaction and time (Rft) of the strengthening slabs with Carbon Fibers

The figures show the strengthening slabs with Carbon Fibers increased fatigue strengths and also increased the resistance of the slabs with wider cracks compared with the other strengthening systems.

This is due to the very high tensile strength, the modulus of elasticity and ductility of the Carbon sheets.

4.1 Slabs strengthening with Shotcrete and Fibershotcrete

The stress and displacements curves for beams are shown in Fig. 8 to Fig 10. Fig 8 shows total displacements and other curves observed (u1) and (u2). Fig. 11 to 12 observed the stresses $\sigma 1$, $\sigma 2$ for slabs strengthening with Carbon Fibers. Fig. 13 the vertical displacement with time but Fig. 14 discusses support reaction Rft reflects the influence of external load with time. for slabs strengthening with shotcrete and Fibershotcrete.

In the analyzing I take the half of the slabs for reduce the number of mesh elements, due to the symmetry of the slab under the vertical loads and in figures the support reaction instead of the vertical loads

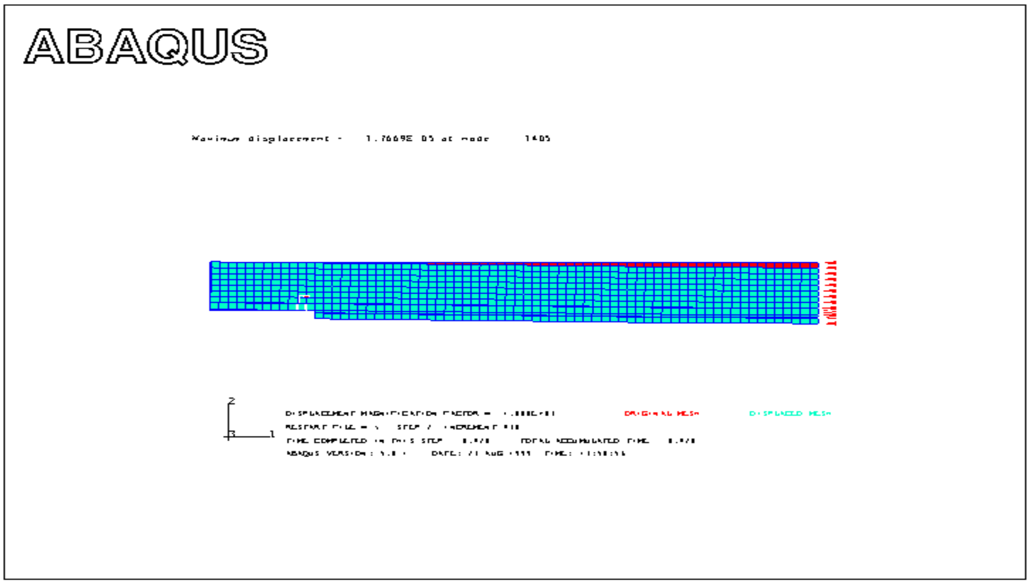

Fig. 8 The vertical displacement(u1) of the Slabs Strengthened with Shotcrete

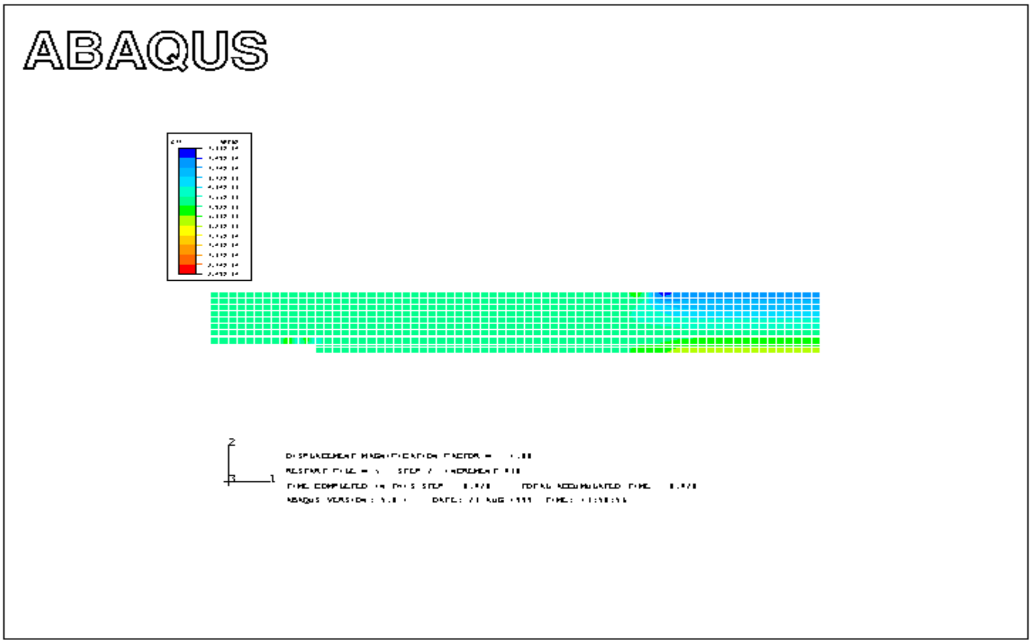

Fig.9 The horizontal displacement (u2) of the strengthening slabs with Shotcrete

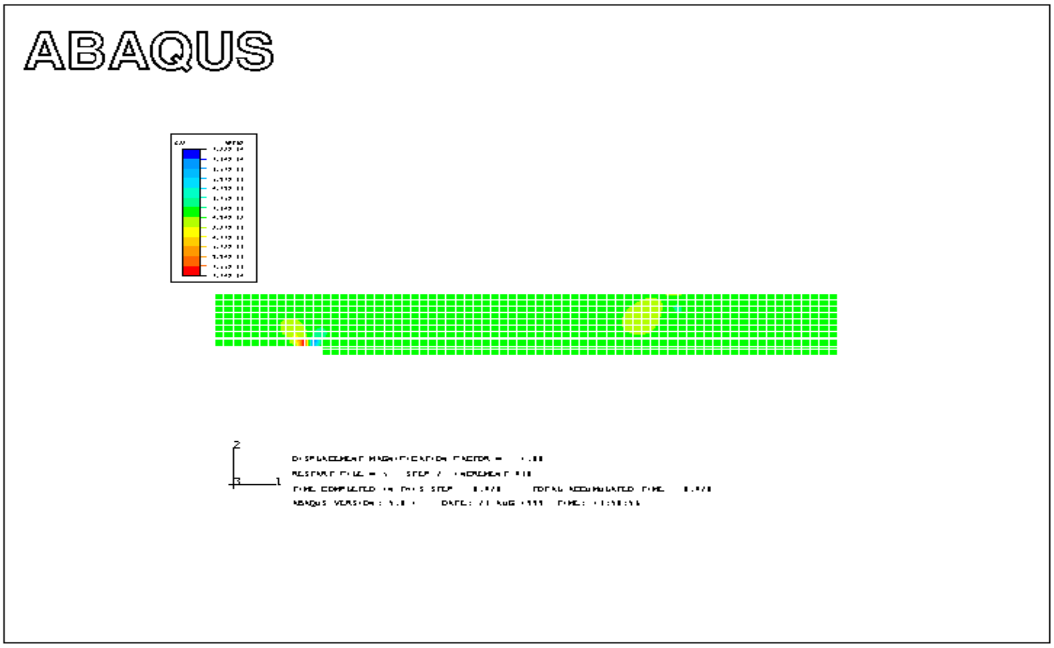

Fig.10 The vertical displacement (u3) of the strengthening slabs with Shotcrete

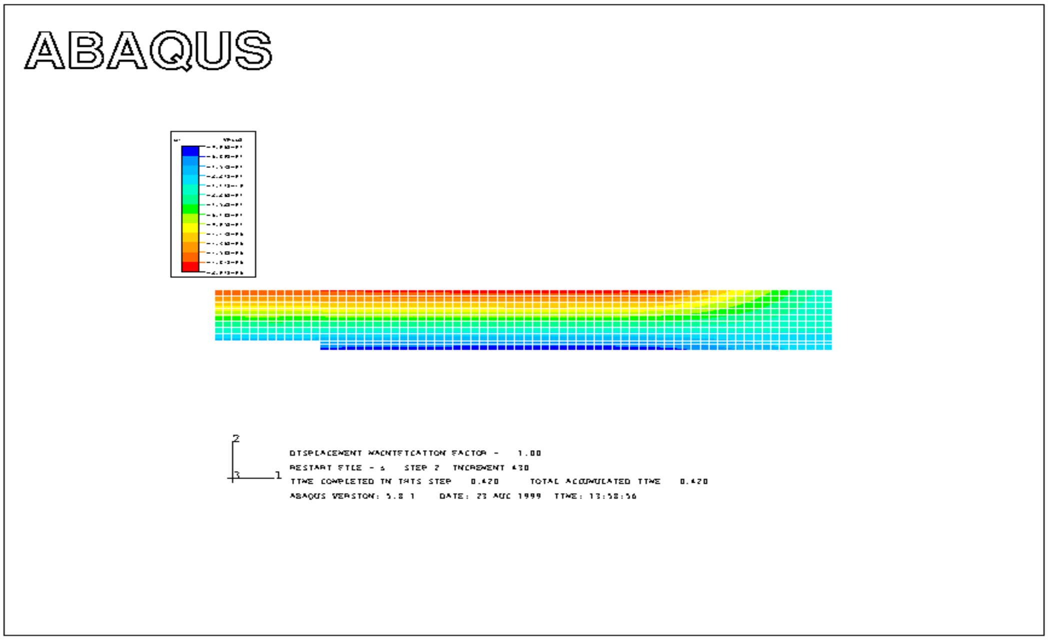

Fig.11 The horizontal stresses (σ1) of the the strengthening slabs with shotcrete

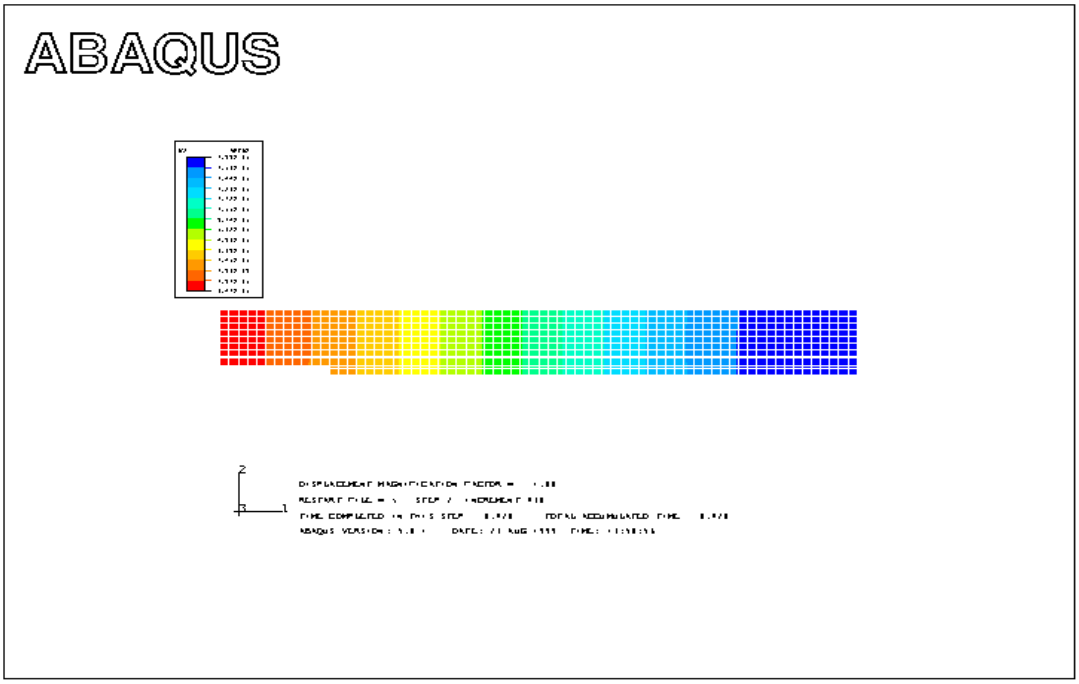

Fig.12 The vertical stresses (σ2) of the strengthening slabs with shotcrete

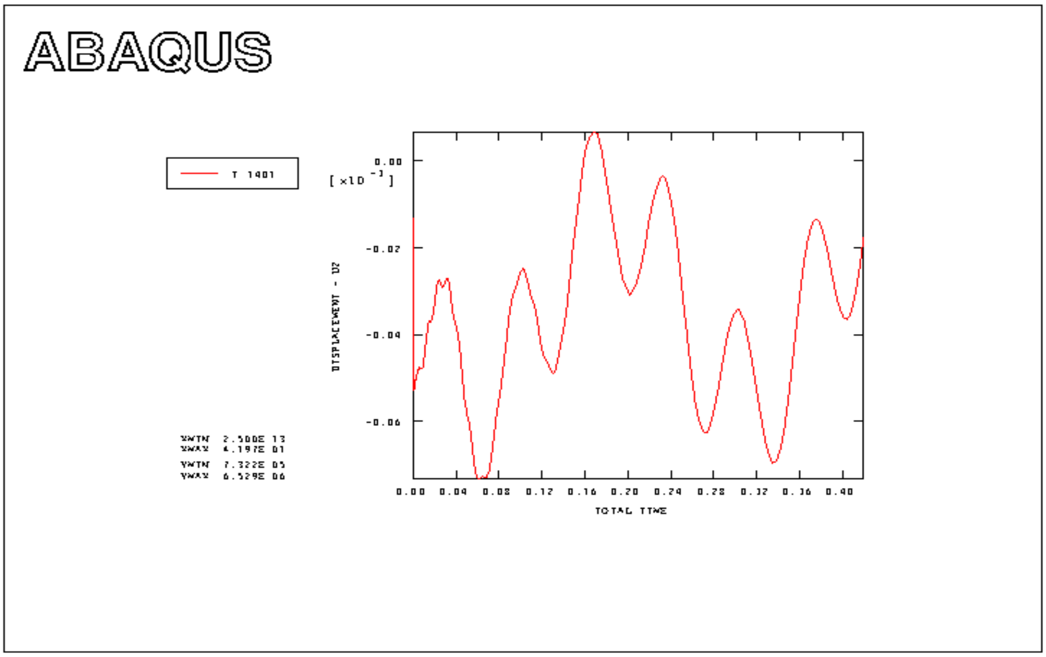

Fig.13 The vertical displacement and time (u2) of the strengthening slabs with shotcrete

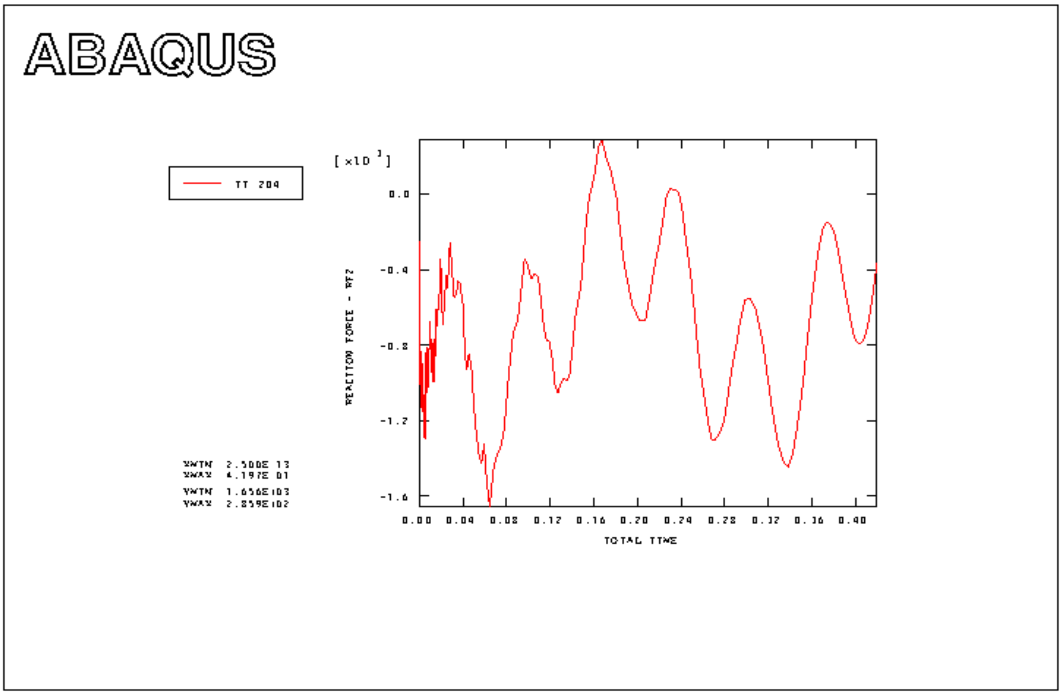

Fig.14 The vertical support reaction and time (Rft) of the strengthening slabs with shotcrete

The fatigue resistance. and due to big contact areas between the old concrete and both SpB and FSpB decrease of the induced shear stress in the contact layers between old concrete and both SpB and FSpB.and subsequently the slabs fatigue resistance big number of cycles.

4-Comparison with the experimental results

Fig. 7 and Fig. 14 show that the support reaction Rft reflects the influence of external load. The curves in this figures indicate that the numerical analysis is in good agreement with experimental results. Also, this figures clearly indicates that the reactions change with the time decreasing and increasing with time depending on the resistance of the slabs against the repeated loads. The mean load between the minimums am and maximums peak loads decrease with the time or after the big number of cycles.

By the same manner the mean of total vertical displacement which take the same trend in the experimental results, that is attained, increases significantly with time or number of cycles. as shown in Fig. 15 to Fig. 17. Figures clear that in the experimental test start statically and then release to zero and the fixed static displacement, after that the repeated loads start, so this gain static displacement fixed all over the test slab process plus to the dynamic displacement which call total displacement or deflection.

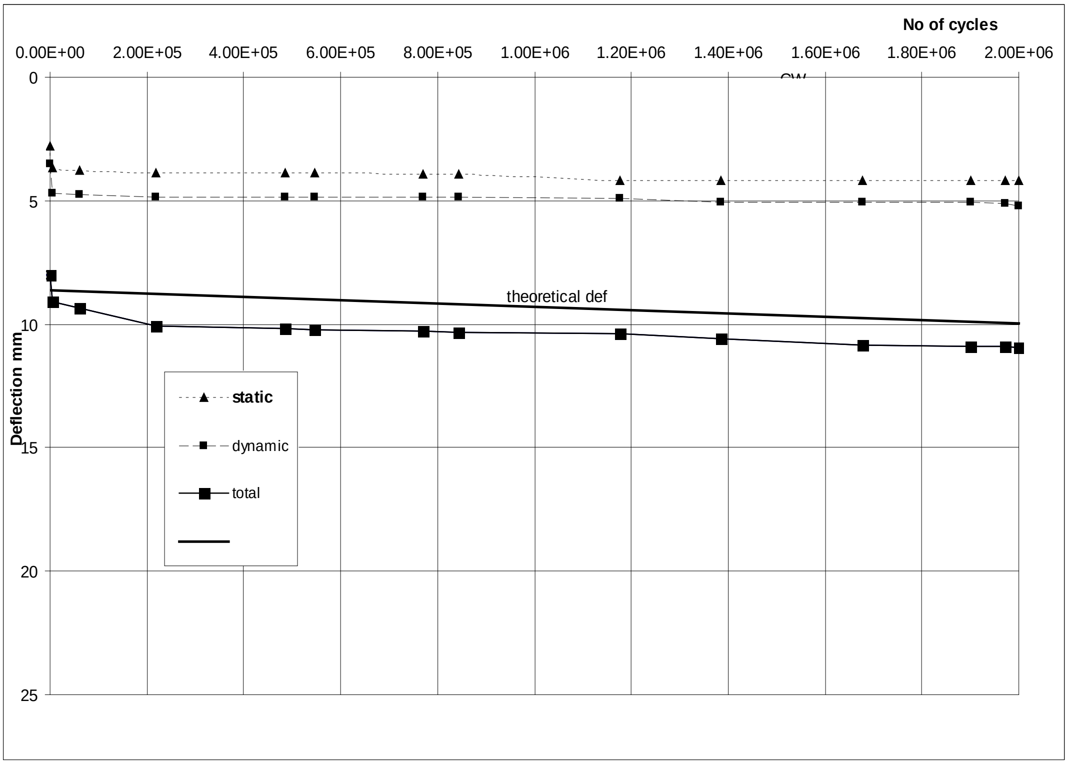

Fig.15 Deflections at middle point and Number of cycles for Slab Strengthening by CFRP

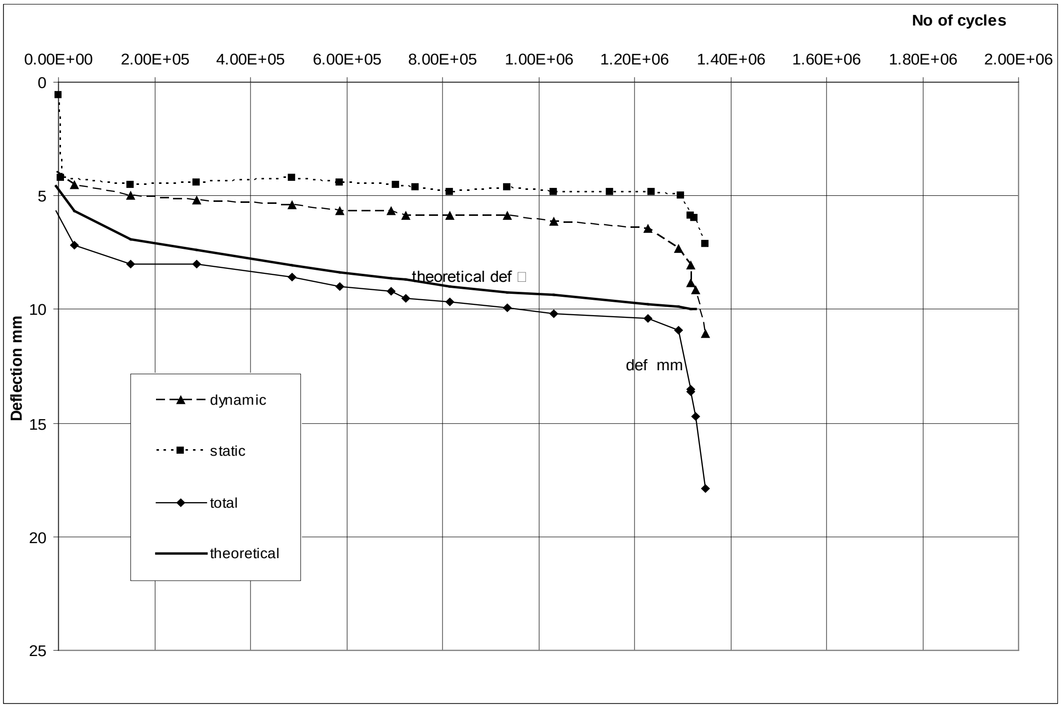

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Fig.16 Deflections at middle point and Number of cycles for Slab Strengthening by SpB

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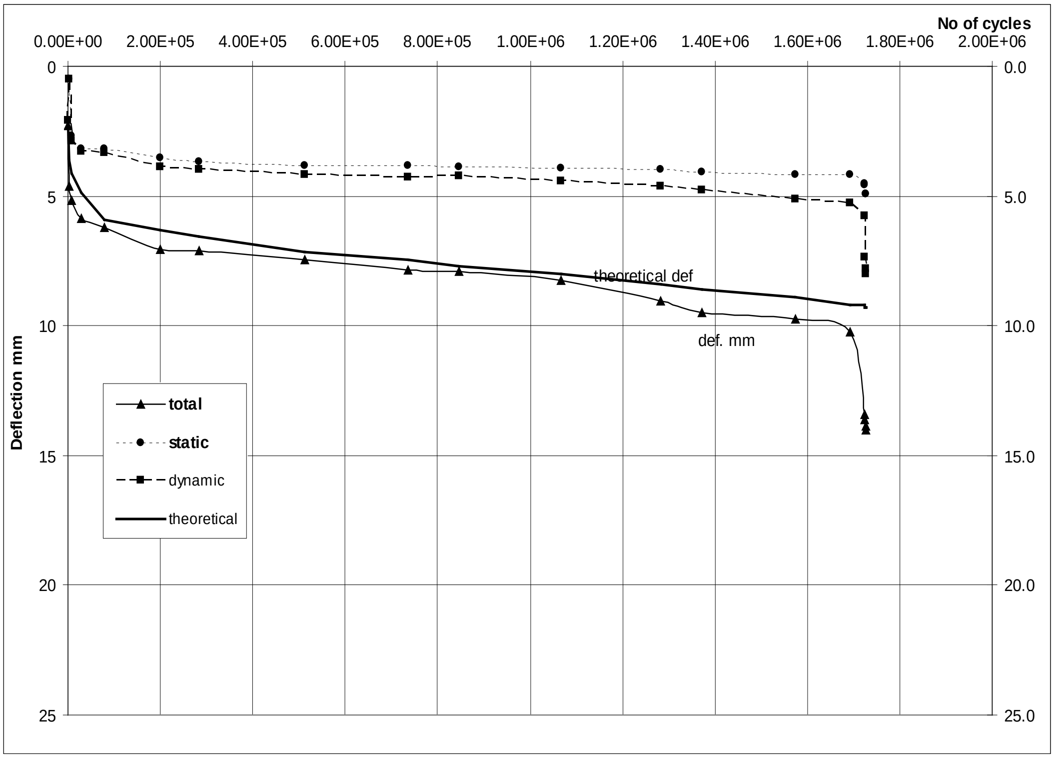

Fig.17 Deflections at middle point and Number of cycles for Slab Strengthening by FSpB

5- CONCLUSIONS

The slab was strengthened with an insufficient area of Carbon sheets; had less fatigue strength and wider crack widths. For this reason good strengthening with systems must have sufficient areas of carbon sheets and these areas must be calculated to give the permissible defections for the reinforced concrete strengthening elements. Slabs were strengthened by externally bonded plates of carbon fiber reinforced plastics (CFRP) is gaining ground due to its advantages over the strengthening with steel plates, slabs were strengthened by 4 deformed bars 10 mm diameter with 2.8 m length and fastened at the ends, then shotcrete applied or Fibershotcrete.

From the above figures, the suggesting formula in the two dimensional for numerical modeling gives results closer to the experimental work in cracking loads, ultimate loads, displacements and the longitudinal and lateral strains are smaller[5].

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