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FE Analysis Of Reactive Powder Concrete –A Review

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Abstract :

In order to investigate the possibilities of current FE programs for implementation of steel fibre concrete this study was conducted. The aim of this study was to show the use of steel fibre concrete with FE calculations, to point out the possibilities and restrictions and to give recommendations for practical usage. The finite element (FE) method offers a powerful and generic tool for studying the behaviour of structures. The power of the FE method is in its versatility. The structure analyzed may have arbitrary shape, arbitrary supports and applied tractions. Such generality does not exist in classical analytical methods, even when the structural geometry is simple.

Key words: *RPC, non linear analysis, ATENA, shear*

1. Introduction

Today's complex construction being planned by a civil engineer is predominantly calculated by means of Finite Element (FE) programs. For this reason it is quite evident that new building materials have to be considered in FE programs to support fast acceptance of them in practice.

Steel fibre concrete is more or less a new building material although the cradle of intense research traces back to the seventies. In order to investigate the possibilities of current FE programs for implementation of steel fibre concrete this study was conducted. The aim of this study was to show the use of steel fibre concrete with FE calculations, to point out the possibilities and restrictions and to give recommendations for practical usage.

It must be emphasized that the programs are rarely used by a civil engineer in practice. This is mainly due to the face that they are often too complex for general applications that are the time for getting to know the work mode does not justify the advantages you get. Furthermore most applications demand merely for linear calculations that is material non-linearity is not regarded.

The behavior of members and structures , specifically their response to loads and other actions, has been the subject of intensive investigation for many years . Because of the complexities associated with the development of rational analytical procedures, present day methods continue in many respect to be based on the empirical approaches using result from a large amount of experimental data. However, challenges in designing complex structures has prompted the structural analyst to acquire a sound understanding of the structural behaviour of concrete structures. In many cases, in non-conventional designs, code provisions cannot be relied upon to provide realistic informational on designs issues such as the load-displacement response and strength and failure modes of a structures and/or its structural elements. Such information is required for safe and cost effective design. In concrete and reinforced concrete structures, the behaviour under loads can be complex. The complexities arise from:

- The non linear stress-strain behaviour of concrete under multi-axial stress states;
- Progressive cracking of concrete induced by the tensile stress field and the consequent crack interface behaviour ;

- Difficulties in formulation of stress and/or strain dependent failure criterion for concrete;
- Complex steel-concrete interface behaviour such as dowel action, bond slip, and progressive destruction of bond in local areas.

The finite element (FE) method offers a powerful and generic tool for studying the behaviour of structures. The power of the FE method is in its versatility. The structure analyzed may have arbitrary shape, arbitrary supports and applied tractions. Such generality does not exist in classical analytical methods, even when the structural geometry is simple. More specifically for concrete issues such as confinement, cracking, tension stiffening, non-linear multi-axial material properties, complex steel-concrete interface behaviour and effects, that are commonly treated in an approximate way, The FE method has thus become a powerful tool that allows the analyses of complex structures and structural phenomena.

While simplified 2D analysis can fully represent all the aspects of the response of structures and structural elements where triaxial behaviour is important. With rapid developments in numerical techniques, non linear 3D analysis of structural elements has become increasingly available.

Also literature reflects that there are two ways of calculating the structural behavior of concrete construction: on the one hand using the smeared crack model, on other hand using the discrete crack model. When using programs with the smeared crack mode, it is aimed to model the global structural behavior. For this case the crack formation depend on the mesh size and configuration. In comparison to the smeared crack model, discrete crack model approach is more precise regarding the local post-crack behavior, but also need more time for solution.

ANSYS is only capable of finding solutions when an ascending branch of the material properties is supplied. That is it is impossible to implement stress-strain relationships that descends. As a consequence material properties of SFC with a strong descending branch cannot be modeled in a satisfying way by ANSYS.

Furthermore the stiffness of the solid element is artificially increased when a Young's modulus of steel fibres is assumed according to the volume ratio when defining the stiffness of the total composite. The effect on the structural behavior is to be considered.

2. Why ATENA ?

In this study, 3D nonlinear FE analyses have been carried out using the FE software ATENA. The ATENA program, which is determined for nonlinear finite element analysis of structures, offers tools specially designed for computer simulation of concrete and reinforced concrete structural behavior. The powerful simulation capabilities of ATENA for modeling the brittle failure of concrete structures.

ATENA program system consists of a solution core and several user interfaces. The solution core offers capabilities for variety of structural analysis tasks, such as: stress and failure analysis, transport of heat and humidity, time dependent problems (creep), and their interactions. Solution core offers a wide range of 2D and 3D continuum models, libraries of finite elements, material models and solution methods. User interfaces are specialized on certain functions and thus one user interface need not necessarily provide access to all features of ATENA solution core. This limitation is made on order to maintain a transparent and user friendly user environment in all specific applications of ATENA.

ATENA 3D program is designed for 3D nonlinear analysis of solids with special tools for reinforced concrete structures. However, structures from other materials, such as soils, metals etc. can be treated as well. The program has three main functions:

- Pre-processing. Input of geometrical objects (concrete, reinforcement, interfaces, etc.), loading and boundary conditions, meshing and solution parameters.
- Analysis. It makes possible a real time monitoring of results during calculations.
- Post-processing. Access to a wide range of graphical and numerical results.

ATENA is the finite element method based material analysis software. The analysis in ATENA involves the following three steps

- Modeling
- Finite Element mesh
- Non-Linear analysis

2.1.Modeling

Modeling is the primary task of any analytical study and the result obtained to a large extent depends on the simplification taken during in this step. Modeling involves creation of geometry of overall structure by including elements of various components representing respective structural behavior including boundary conditions in the considered problem, Material properties of various elements and loads on various elements and its combinations were defined. The various steps involved in the modeling are as follows.

- Units were set for the convenience.
- Define the properties of various materials used in the models.
- Draw the model (macro-element) in the graphical environment.
- Define different loads
- Assign properties to the model.
- Assign the various loads on the models.
- Assign the various supports on the models.

2.2.Finite Element Mesh

After the definition of macro-elements is completed it is possible to proceed to the next step in the definition of the numerical model that is the automatic mesh generation. In ATENA, each macro-element can be meshed independently. Three main options exist for the macro-element mesh generation. It is possible to create a structured mesh that consists of only brick elements. Such a method is possible only for macro-elements that have six boundary surfaces. For other macro-elements that do not fulfill this requirement tetrahedral or mixed meshes can be created. In the case of mixed meshes, the program attempts to create a uniform brick mesh in the interior or the model. The remaining regions close to the boundary are them meshed with pyramid and tetrahedral elements. This method works satisfactory only if the selected mesh size is sufficiently small. If the specified elements are too big the program fails to create the uniform brick mesh in the interior of the macro-element, and only tetrahedral elements are created.

2.3. Non-Linear Analysis

Once the model is built, the non-analysis is performed after defining the various loads and supports.

The following general sequence of steps involves in performing nonlinear analysis:

- Create a model (macro-element) just like any other analysis.
- Define macro-element properties.
- Define any load and analysis cases that may be needed for concrete design.
- Run the analysis cases needed for design.

The CC3NONLINEAR CEMENTITIOUS2 is suitable for fibre reinforced concrete, such as SHCC (strain hardening cementitious composites) .Tensile softening regime and the shear retention factor are modified based on the model, proposed in KEBELE, P .This model is based on a notion of a representative volume element (RVE) which contain distributed multiple crack (hardening) as well as localized cracks (softening) the overall strain of the RVE is then obtained as a sum of strain of material between cracks (which may possibly contain non linear plastic strain due to compressive yielding),cracking strains due to multiple cracks, and cracking due to localizes cracks.

In this study an inverted 'L' shape specimen with varying depth of shear plane is studied and results are compared with the experimental results by keeping same loading and material of RPC.

In post processor mode output Results for the model, with different interested parameter with Iso-Area can be seen. Some of them are attached for Beam and L-Shape specimens.

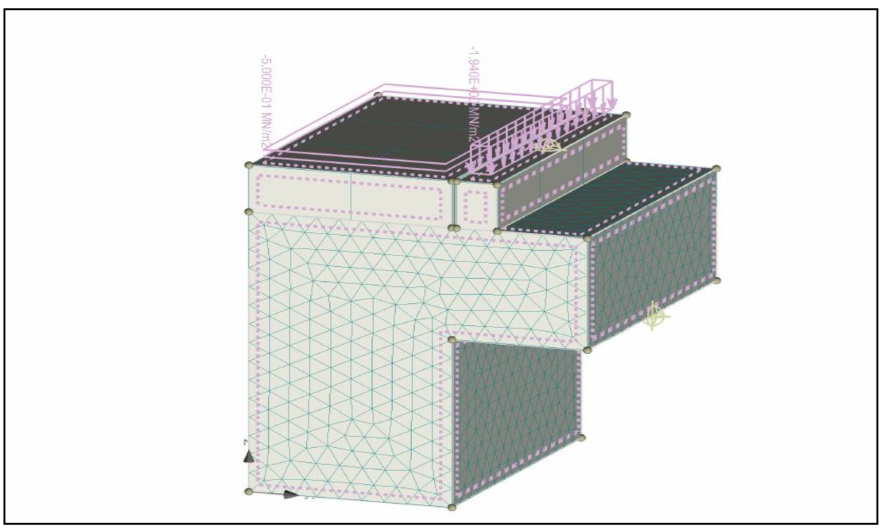

Figure 1: General Arrangement of specimen with FE mesh

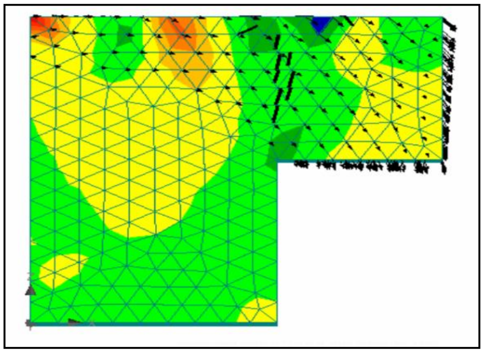

Figure2: Crack Propagation In Specimen

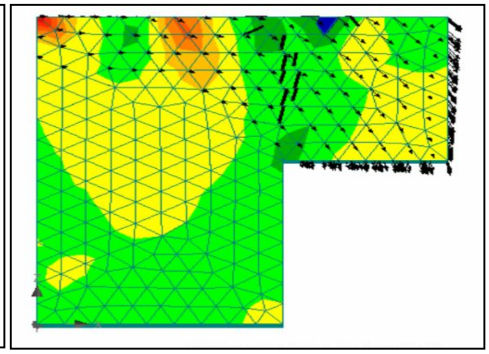

Figure 3: Displacement in a Specimen

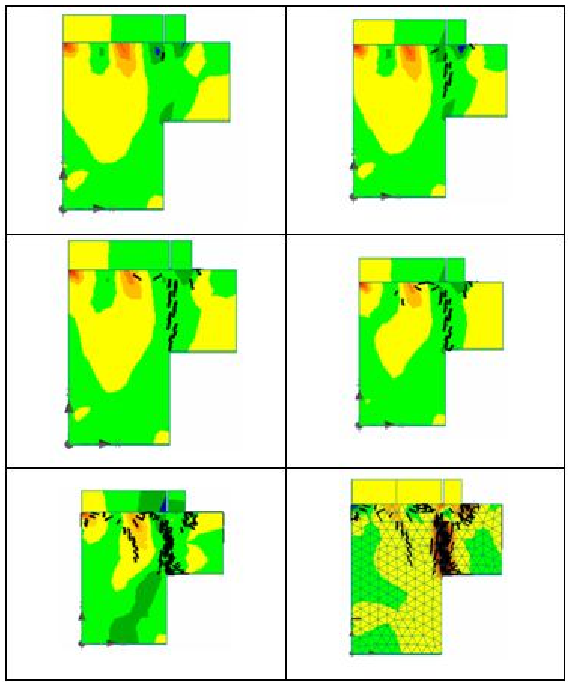

Figure 4:Crack Propagation In Specimen

To the presence of dominant shear stresses, the specimen geometry was studied using finite element analysis, the stress concentration are obtained as shown in Fig.4.0 indicating the possibility of cracking. The shear stress distribution is shown in Fig. 4.0 with darker zone indicating higher stresses. It can be seen as that there is a zone of shear stresses at the junction of "L" shape specimen, conforming that shear failure would occur if tensile cracking was to be restrained by fibres. As a result clear shear crack propagation can be observed at the junction of "L" shape specimen.

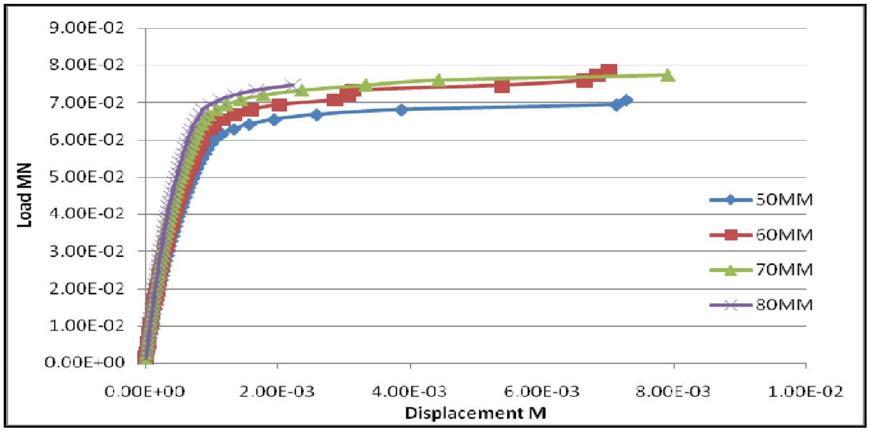

Figure 5: Load Displacement Relation with Thickness Of Shear Plane Using ATENA

The load deformation results of the FE modeling for 60 mm and 70 mm thickness of shear plane generally compare well with the test data. The FE results of the 80 mm grossly over predicts the failure load. It is worth mentioning that 50 mm thickness of shear plane fail somewhat prematurely because of the localized crushing and tensile failure. A good co–relation between results of FE analysis experimental values can be obtained using "ATENA" having powerful simulation capability. It is using model propose by KEBELE, P. the model is based on notion of representative volume element which contain distributed multiple crack as well as localized crack.

Looking at the displacement corresponding to peak load, it would be expected that the influence of the existence of fibres on the response of the RPC would be to induce some degree of plastic behavior.

The toughening observed in the test is a result of the pull out and dowel action of the fibre during the shear cracking. The pull out resistance tends to close the cracks, while the shear forces tends to open it due to the irregularity of the crack face ,produces a confining effect which together with the dowel action of the fibres and friction between the crack faces, can lead to an increase in the shear strength.

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