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Study on the Behaviour of Beams under the Chemical Attack by Using ATENA Software

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ABSTRACT: concrete structures, whether plain or reinforced, will be exposed to various chemical agents, which are anticipated to lead to premature deterioration unless appropriate protective measures are taken. In coastal environment reinforcement corrosion is the obvious cause for the deterioration of the concrete structure, which effects the durability and service of the concrete structure. This paper presents an experimental program to investigate the disparity between the load deflection curve of beam subjected to chemical attack and those without such exposure. In the experimental phase a total of 50 cubes concrete specimens casted from M30 grade concrete. And cubes which will subsequently be exposed to the aforementioned chemicals to extract the desired results regarding target mean strength, which will serve as crucial input data for establishing material model parameters in ATENA software.

I. INTRODUCTION

Concrete is one form of construction with high popularity attributed to it due to its stability and workability. Nevertheless, it cannot be completely immune to damage from some of the chemicals that it comes into contact with. When exposed to these chemicals, concrete can have the problems that are connected with structure or reduced duration of life. This type of chemical damage occurs in any environment and under any condition it is subjected to whether in the home, at work place or even in any other place. There are different types of chemical attack on concrete:

Acid attack: Sulphuric acid, hydrochloric acid, or other acidic industrial waste that contain the sulphates ion can attack calcium hydroxide and calcium silicate hydrates which are found in concrete. It is a chemical reaction that has an effect of breaking down the concrete matrix, making it to crack, and become structureless. Acid attack is an issue that affects industries such as chemical manufacturing, waste water treatment and battery production.

Sulphate attack: Sulphates which may occur naturally in the soil or water, or can be introduced from external sources react with the calcium aluminate phases present in cement to form expansive deleterious sulphate products. This anionic reaction may cause the concrete to crack, the mechanical strength of the concrete to be reduced and the concrete to degrade. Sulphate attack is one of the main problems associated with construction of underground structures, marine structures and buildings located in regions with high sulphate content in the soil.

Chloride attack: Chlorides, which can be seen in sea water, de-icing agents or industrial atmospheres, can get into the concrete and attack reinforcing steel. Chlorides are known to start the corrosion process of steel bar and cause rust formations, which in turn expands the crack, causing fracture of concrete layer. Chloride attack is a Chloride relevant problem in areas with a high concentration of salts and therefore is common in coastal areas as well as areas that use de-icing salts.

ATENA Software (Advanced tool for Engineering Nonlinear Analysis): Another utility of using ATENA for the FEAs is that it derives all material properties from the cube strength with the help of equations. Yet another strength with this program is that it is developed for concrete which puts the user in an advantage since sensible d values are provided. The main benefit is that while the exams described serious cracking the program was not faced by any issues in finding a convergence solution at any point in time. Multistage sampling was adopted by Naga Chaitanya et al [1]. According to the findings of this research work, it can be concluded that load carrying capacity is high for control beams but deflection is low for control beams than that of corroded beams. Corrosion affects the material property known as the

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ductility where if corrosion increases the ductility property decreases. It also observed that the crack width is higher with the rate of corrosion. Zdenka Prochazkova et al [2] found out that this tutorial offers a systematic guide for using ATENA – GID employing the reinforce concrete beam. As stated in the study conducted by Tammer Ei Maaddawy el at [3], the rate of corrosion crack width was found to have increased for the loaded beam at approximately 22% higher than that for the unloaded beam at the starting stage. Holly et al [4] study shows that the corrosion of reinforcing steel affects the bond strength. The loss of bond strength is more severe than the loss of bars cross section. The bond strength can be reduced by 50% while the loss of reinforcement area is only 12%. compared to specimen without stirrups, those with stirrups exhibit higher residual bond strength and are less affected by corrosion. Jan Cervenka et al [5] study shows that reinforcement corrosion due to chloride ingress. Implanted models in ATENA software allow the simulation of most important degradation events during the life.

II. MATERIALS

Cement:

The cement used in the present study was ordinary portland cement (53 grade). It was tested as per IS: This recommendation is alike the 8112-2013 recommendation for the cement. It also mean that it got the requirement of code book to obtain those results.

Table:1: Fresh properties

S.NO	Test parameters	results	Specification of OPC 53 grade
1	Initial and final setting time	78 and 260min	Not less than 30and not more than 600min
2	Specific gravity	3.14	

Fine aggregate:

In this given study the fine aggregate was obtained from the river sand available in the local area. The sand which was sieved through 4. 75mm IS sieve and falls under grading zone II which conform to the code book requirement of IS 383-2016 and its specific gravity is 2.67.

Coarse aggregate:

The coarse aggregate used in this project is 20mm size and 12.5mm size angular type shape aggregate. And it has a specific gravity of 2.63.

Super plasticizer (SP):

In our study we used Auramix, a high range water reducing admixture that was produced by FOSROC. This agent was used with a view to reducing the proportion of water in the mix as provided by IS 9103:1999(2007) and ASTMC49(2015). Some of the basic parameters of Auramix include; Auramix specific gravity being 1.222.

III. METHODOLOGY

Concrete mix and design:

Considering the large amount of concrete needed for the construction, Ready Mixed Concrete is used for preparation of the specimens. Therefore, several trial mix designs are carried out in the laboratory to obtain a slump range of between 80-120mm and cube strength of 30Mpa. This trail concerns in altering the amount of cement, water cement ratio and the content of admixture in order to achieve the near perfect concrete characteristics.

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Table: 2: Materials

Ingredients	Quantity
cement	380Kg/m^3
Fine aggregate	727Kg/m^3
Coarse aggregate	1290Kg/m^3
water	160Kg/m^3
W/C Ratio	0.42
Mix proportion	1:1.77:3.14

Casting and curing of the specimen:
Casting of 50 cube members and beam specimens of concrete mix to find its corresponding compressive strength. The moulds were oiled and then the empty 3 specimens are filled with the concrete mix in batches. Following execution of concrete works, vibration was made to allow proper compaction of the concrete. The specimens were dried in air 24hours of casting and the other samples were casted in the curing tanks and cured to another 28days. And after that the samples were removed from the solution in the dry environment for testing.
Results of casted cubes:

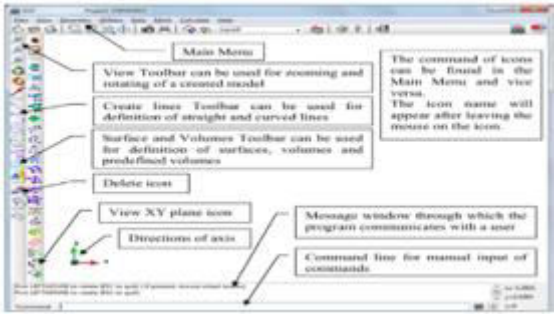
Table: 3: Results of casted cubes:

S.NO	Compressive strength	results
1	7 Days	26.01(N/mm^2)
2	14 Days	36.01(N/mm^2)
3	28 Days	40.02(N/mm^2)

Chemical curing: following the extraction of the cubes from the curing tank they are returned into the chemicals for chemical exposure condition which causes chemical attack. Cubes were immersed in the chemicals as stated above and cured for nearly 56 days and standard compression strength test was conducted at 7days, 14days, 28days and 56days.

Design of beam by using ATENA Software:
The program GID is an initial and final preliminary analytical (and analysis software) tool for a number of numeric exercises. In this menu, one can define a problem type and here we have defined an ATENA analysis. Steps for the design of beam: Steps for the design of beam:

The GID program can be started from the menu of your computer using the following manner: Begin with | Each of the programs | Cervenka Consulting Service | ATENA Science | GiD. This leads to the opening of the GiD program that will be utilized in preparation of the numerical model for analyzing of the structures.



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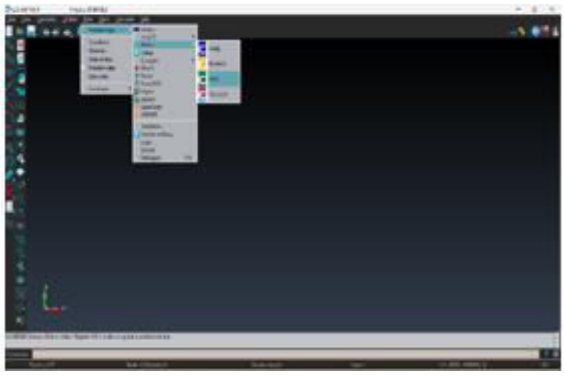
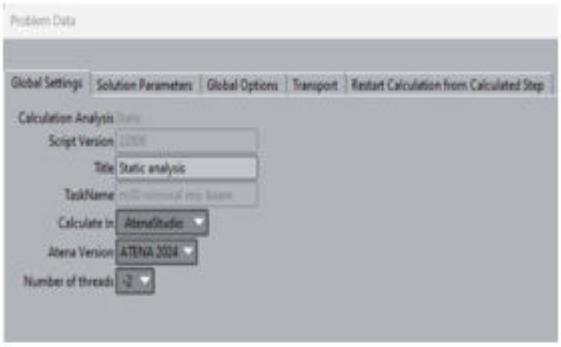
The specific type of the problem is chosen in the main menu of the program Data or Problem type, ATENA, Static. Following a new window is opened selected with icons.



To close the file and also to continuously make the built geometrical model: File >Save used to store the created model while preparing a geometrical model. It can be saving done by the icons at the top of the program, through File |Save or Save as. We can name for the model as nominal mix beam. When creating the model it is always best to declare the global parameters before arriving at the parameters of the model. It is done by Data | Problem data |.



Concrete beam: in this section, the user is provided with the understanding of the concept of three-dimensional geometry beam. The first step is to construct ‘points’, out of which a rectangular surface will be formed following the next steps. A point is created with the help of the following command placed in the main menu Geometry | Create | Point.

Parameters input:
1.(0,0,0)
2.(0.9,0,0)
3.(0.9,0.15,0)
4.(0,0.15,0)

The next step is to join each of these points by lines in order to complete the picture. A line is drawn using Geometry menu, Create, Straight line option from the main menus. Here are some detailing of the process done through various steps The directly picking done by selecting both Ctrl + A in the keyboard. And next step is the creation of the surface with the help of the lines that already drawn.

The further procedure is bring the created surface to the volume to get the require beam in the desired shape. This is copied using the submenus Copy which appears after calling the main menu Utilities | Copy.

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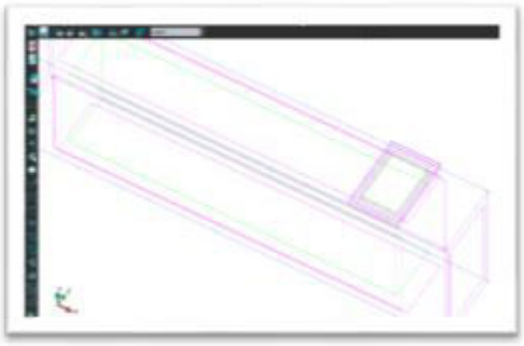
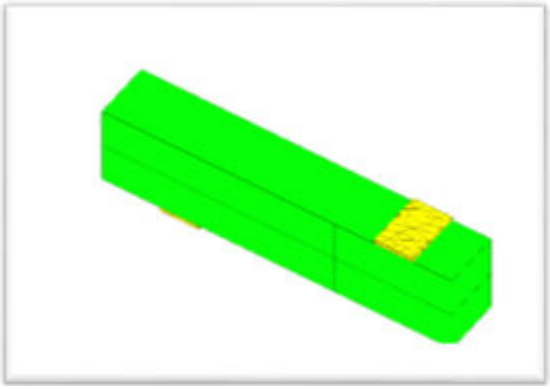
Loading and supporting steel plates:
Following the design of the beam geometry loading and supporting of the steel plates will be developed. The first design to be made will be the top plate or loading plate. The lower plate or supporting plate shall be made by copy of the upper plate. These commands make copy and create lines on the top line plate as well as crating the surface.



Reinforcement bars:
Reinforcement bar geometry will be drawn by clicking the line icon that appears at the top of the software or by going to Geometry | Create | Straight line from the toolbar.

Layers:
Layers are the useful feature for the of GiD. It is possible to take apart the specifics of the geometry into layers within which they will be distinguished.
Material properties: This beam has three constructs to include; these are concrete, steel plates and reinforcement bars.
Concrete beam: It should also be noted that the material of concrete can be created by the key Data | Materials | Solid concrete in the tool bar.
Loading supporting steel plates: And the material definition can be begin with the key Data | Materials | Solid elastic in the tool bar.
Reinforcement bars: The material can be inserted by using command Data, then select Material then finally 1D reinforcement.
All the properties of the material have been inserted to the respective beam and this can be completed by clicking on the assign key in the bottom of the material window.



Boundary conditions: And next beam is also sandwiched to the lower plate in the y axis direction manner. The analysis is exclusively of the symmetric condition of the beam. The beam was loaded at upper portion of the steel plate. The forces, the displacement or stresses should be checked during the non-linear analysis of the object.

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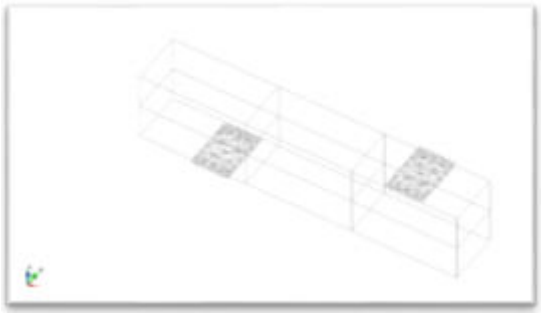
Intervals – Loading: The loading type in GiD is based on intervals. 'Number of load steps' divided into each interval. The objective is to slow down the load up failure and gradually develop it.

Mesh generation: The mesh generation is one of the processes in pre-process with tools used in producing a mesh model. Mesh properties that are appropriate for the program will also be determined by the program. This activity can be done by key Mesh | Generate mesh (or) can also done by clicking Ctrl+g.



Fe non-linear analysis: The finite element analysis is initiated by picking on the icon which is located in the tool bar or use of the F5 key. Upon the click, there will be creation of the Non Linear ATENA input file and after that; The ATENA studio will open and the analysis will begin.

Load - Displacement curve: When analysing it is upon time useful to fixed the applied load and beam deflection. This will have its name as deflection or displacement in the horizontal series while the vertical series will be named as the load. Information of the load deflection curve is displayed in the panel on the left part of the ATENA studio interface.

Parameters input:
Diagram title: load-deflection
Horizontal axis: deflection [m]
Vertical axis: load [MN].

IV. RESULTS AND DISCUSSION:

These cube specimens were casted as describe earlier However the concrete cubes were casted using the following procedures. And the specimens were exposed to the chemicals for curing of the chemical exposure condition. And further the specimens were subjected for compressive testing using compressive testing machine abbreviated as CTM.

Table 4: Compressive strength after chemical curing

Days	HCl	H_2SO_4	CH_3COOH	NaCl
7	38.92	38.21	39.81	39.92
14	35.47	35.12	39.15	39.13
28	34.17	33.24	37.93	38.25
56	29.23	28.35	36.37	37.52

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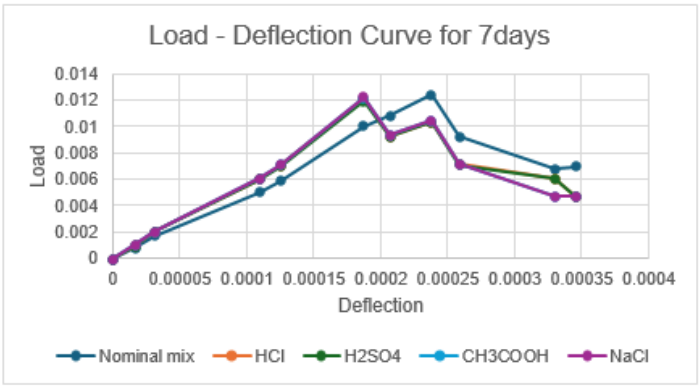
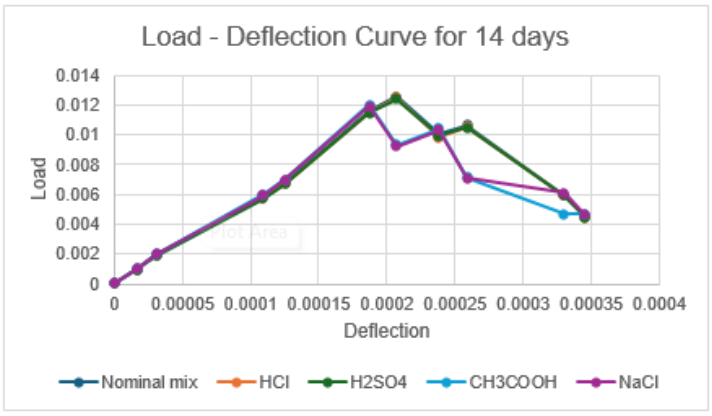
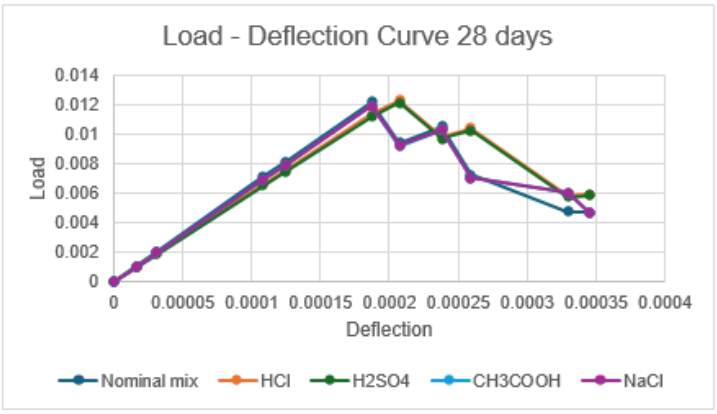
when testing of the control cubes it was noted that the control cubes cracked at an ultimate load of 40. 2 N/mm2 and for the chemical exposure cubes failed at HCl at 28 days 34. 17, H2SO4 at 33. 24, CH3COOH at 37. :93 and NaCl at 38. 25 respectively. Research showed that chemical attack led to the decrease of the compressive strength of concrete.

Load – deflection curve: load-deflection curve means an vsing curve that illustrates the type of relationship between the load and the deflection. This represents the area under the top graph which shows the work done in order to deformed structure.







Using the ATENA software, this study has shown that chemical attack reduces the performance of concrete beams in a very big way. A comparison on the deflection of beams exposed to chemical attack and the control beams showed that

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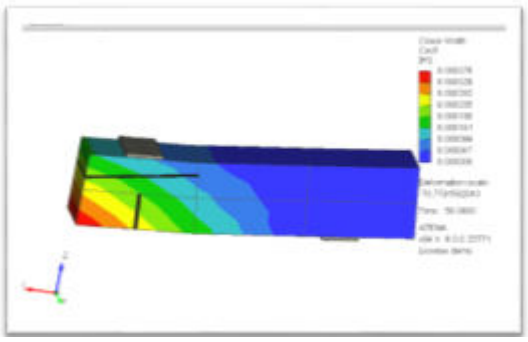
the former had a higher deflection than the latter. That was computed and seen that peak load taken was maximum in non-exposure chemical beams that is in control beams. This bending was noticed to be higher for the chemical exposure beams compared to non-chemical exposure beam.

1. In this connection, what has been found out was that 7days deflection of the controlled beam was 0. 000238m for the load of 0. In the peak load for chemical exposure, it seemed 01248MN like 0. 01037MN, 0. 01030MN, 0. 01047MN, 0. When using the HCl, H2SO4, CH3COOH and NaCl the numbering system is as follows; 01049MN.
2. As far as the finding of the experiment is concerned it is found that for 14days deflection of controlled beam was 0.000207m for the load of 0. It was about 0. 0125MN peak load for chemical exposure that it was like 0. 01247MN, 0. 01242MN, 0. 00931MN, 0. The observed molecular ion peaks were 00922MN corresponding to HCl, H2SO4, CH3COOH and NaCl.
3. It is observed that for for 28 days deflection of a controlled beam was 0. The load merged in correspondence with a designation of 000187m for the load of 0. At its peak load for chemical exposure shift 01217MN, it was as if 0. 01132MN, 0. 01118MN, 0. 01188MN, 0. Update: HCl, H2SO4 and CH3COOH, NaCl will be 01192MN.

Crack width: The width of the cracks on the surface should not be more than 0. 3 in members where cracking is not detrimental and does not affect the durability of reinforcing steel and life of the structural elements. The initiation of corrosion apparently is predicted to happen mainly at the stirrups then the main reinforcement which is covered by concrete. In corroded beams, red and brownish coloured rust can be observed in different parts of the beam. If the tensile zone or cracking zone of the beam is exposed to moisture content or the chemical exposure then the crack width should not be more than 0. 2mm. for high intensity conditions such as category of severe conditions, the surface width of the crack must not exceed 0. 1mm. the crack width pattern for symmetric condition beam as below: the crack width pattern for symmetric condition beam as below:



We also noticed that crack width of the beam is greater than the 0. 3mm in every exposure. Regarding the exposed chemical conditions for the chemicals utilized for the experiments, crack width was measured to be between 0. 32mm to 0. 35mm. lavishly we can see in HCl chemical exposure mostly we observed.

V. CONCLUSION

- Based on the experimental analysis it has been found the load carrying capacity is more in control cubes than the chemical exposure cubes from the investigation.
- Within chemical exposure it is seen that the cubes are contributed to decreasing the strength because of the breakdown of the concrete materials.
- Minimum deflection for the controlled beams is less as compared to the chemical exposure beams.
- The peak load control beams is greater than the chemical exposure condition.
- Numerical cracks under developed on the control beam and on chemical exposure are same but the difference is crack width.
- Controlled beam has the least size crack width compared to the chemical exposure beams.

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VI. FOR FUTURE WORK

They continued with the investigation on the various beam sizes to ascertain on the effects of the crack and the deflection.
More research should be done on the varied chemical compounds in order to determine the actions of the beam under various circumstances.
With different load conditions and different load combination we are able to analyse the behaviour of the beams.

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