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High End Solution for Advanced Civil Engineering Projects

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Abstract: *Civil FEM performs the best customization of the well-known Finite Element Program ANSYS. The combination of both programs, totally integrated, provides the Construction and Civil Engineering fields with the possibility of applying high-end technology to a wide range of projects. Using the same windows graphic user interface and sharing input data and results, makes it very easy for the user to apply them for solving difficult Civil Engineering problems. The ability to generate finite element models of any complex three-dimensional civil structure with non-linear behaviour and construction process simulation means a new and efficient approach to run advanced analysis on PC's.*

Keywords: *Section library, load combination, Beam and shell utilises, Resource Scheduling,*

I. Introduction

Civil FEM is at the present time one of the most advanced tools that engineers can embrace, a project that is committed with a time and with a permanent vocation of investigation and development. Civil FEM capabilities include a unique and extensive materials and sections library for concrete and steel structures. In addition, the user may introduce any shape or material into the corresponding CivilFEM libraries.

A user-friendly beam and shell postprocessor includes listing and plotting section geometry, reinforcements, beam results or stresses and strains inside the cross-section. The skilled combination module, selects loads and coefficients for logic code combinations. Results embrace concomitance at element and global level as well as worst load arrangements in beam, shell and solid elements.

In the field of Seismic Analysis, the designer is provided with an automatic seismic design module according to Eurocode No.8, UBC, NCSE-94 (Spanish Code) and others to make the seismic spectrum analysis faster and easier. CivilFEM also performs concrete and steel code checking and design according to Eurocodes (EC2 and EC3), American (ACI318 and AISC-LRFD), British (BS8110 and BS5950-1995 and 2001), Spanish codes (EHE and EA), Model Code (CEB-FIP) and other main codes. With regards to serviceability, CivilFEM conducts for the aforementioned codes cracking analysis. CivilFEM specialized add-on modules include non-linear concrete, soil mechanics, prestressed concrete, bridges and dams features. The non-linear concrete module supports large deflection buckling, non linear deformations, moment-curvature diagrams, cracking and transient effects.

For soil mechanics, slope stability analysis, libraries of soils and rocks properties, screens analysis and design, nonlinear behaviour analysis and ballast module computation, will allow the user to carry out advanced geotechnical problems.

The features and prestige of ANSYS in the finite element world, combined with CivilFEM's capabilities and specialized modules, translates into a fully integrated state of the art Civil Engineering working tool. This advantageous and unique bundle product represents the possibility of applying the analysis with finite elements to a wide range of problems according to the hardships and requirements of this field.

II. CivilFEM Integration with ANSYS

CivilFEM works inside Ansys program. That is, all Ansys tools may be used with CivilFEM (APDL, UIDL, optimization, graphical output, ...), the CivilFEM menus are integrated inside the Ansys Main Menu, CivilFEM Help is managed as Ansys Help System, CivilFEM commands are generated by CivilFEM menus and written to the Ansys log file, and so on.

Ansys results are stored in CivilFEM results file in addition to data related to the cross section. You may switch between Ansys and CivilFEM processors at any time, and mix commands from both to generate, solve and postprocess your model easily. CivilFEM implementation is based in the use of dynamic link libraries (DLLs). These libraries contain the CivilFEM code and are incorporated into Ansys executable file in execution time, working as if they were part of Ansys. This structure allows to connect with the DLLs by means of ANSYS external commands. These commands are declared in file ans_ext.tbl CivilFEM menus are elaborated using Ansys UIDL features. All CivilFEM windows are written in Visual C++ and Dll's in Fortran. Like Ansys, CivilFEM may work in any system of units. However, the user must specify the units system before any CivilFEM calculation is done, since specific code formulations and CivilFEM tools depend on units. A library with the most usual (American and European) units in Civil Engineering is available. Furthermore you may also define any other unit system (not available in the library) by selecting the "User Defined Units".

III. Civil Material Library

CivilFEM defines the mechanical properties required by Ansys and the specific properties needed for code checking of usual civil materials, in accordance with code specifications. This library includes materials from most usual standards.

Nevertheless, the user is provided with the necessary tools to add materials into this library. Using this tool, modified materials or new materials from any code may be included. CivilFEM material's library has five classes of properties for all CivilFEM materials:

- General properties: Common to all the materials.
- Structural analysis diagram: stress-strain diagram used when solving the model.
- Design diagram: stress-strain diagram used when checking or designing a cross section.
- Specific properties depending on the material: steel, concrete, soils, rocks.
- Specific properties depending on codes: EC2, EC3, ACI, BS8110, BS5950-2001, LRFD,...

Moreover, user materials may be saved in CivilFEM's material library. Material properties in CivilFEM are time dependent which means that the user can solved the same model at different ages.

For each one of these scenarios, materials used in the model will be active or not, depending upon the age of the material. The program will calculate the material age by subtracting from the age solicited the birth time of the material.

With this capability, the user can simulate construction processes, not only at element level but inside the cross section as well. For the non linear structural behaviour, a graphical control of stress-strain curves enables the user to select the graph that best represents the different types of loading of the structural analysis.

The user may also add or delete points, or simply create his/her own curve (See Figure 4). Different relationships between stresses and strains are also provided for sections design, with the same possibilities as for the structural stress-strain curve.

IV. Section Library

All cross sections in CivilFEM are divided automatically into points and tessellas. A tesella is a subdivision of the cross section and each tesella's vertex is a point. This particular characteristic of CivilFEM's cross sections, allows the program to analyze and provide results inside the cross section. Cross sections in CivilFEM can be defined using eight different procedures:

1) The library of hot rolled shapes:

This library contains the most international sections libraries, such as hot rolled shapes distributed in Europe by ARBED, as well as all the hot rolled shapes included in the AISC LRFD (over 4000 hot rolled steel shapes are included). These last two series include all shapes groups in metric and U.S. units.

2) User library of hot rolled shapes:

CivilFEM enables the user to add more hot rolled shapes into the existing library. This capability is two folded. The user may either read mechanical or geometric properties from a file or introduce the geometry corresponding to the selected hot rolled section using a specific CivilFEM window. In the latter case, CivilFEM will automatically calculate the mechanical properties for the section entered by the user. Using this tool, shapes from any country may be added.

3) Definition of sections by dimensions:

The most usual welded steel sections as well as the most usual concrete sections may be defined by dimensions. In the case of reinforced concrete, a preliminary reinforcement may be defined using the predefined options offered. Nevertheless user reinforcement layout for bending, shear or torsion is also available in CivilFEM.

4) Definition of sections by plates:

Each plate adopts the active material. This feature allows defining a generic steel section built up with 2 to 100 plates with the possibility of having different materials. For each plate the ends coordinates, thickness and restraint conditions need to be specified.

5) Definition of sections starting from a 2D mesh of virtual elements MESH200:

This feature allows the definition of sections with any shape and even with mixed materials (different concrete strengths or concrete with structural steel) using Ansys elements MESH200. Each teselum (subdivision of the cross section) will adopt the material assigned to the corresponding element once the cross section is captured by CivilFEM. Export of CivilFEM sections into Ansys are also possible.

6) Definition of beam cross section inside a 3D solid model of finite elements:

Each teselum adopts the material from the finite element to which is associated. The SOLID SECTION (cross section coming from a 3D ANSYS model) and the CROSS SECTION (transverse section as commonly understood in engineering) are defined simultaneously and their numbers coincide.

This capability allows to build and solve a complete 3D solid model of the structure, and then select sections inside this model to be processed by CivilFEM. This feature allows code checking and design of all user defined sections of 3D

7) Composition of sections:

Any section defined by any of the above means can be combined with any other concrete or steel section and form a new section

8) User data base of sections:

Any section defined by any of the above means can be stored in a user data base for later use.

CivilFEM uses its Beam & Shell property window to easily select the section for element ends i and j. The corresponding element type must also be entered in this window, and the real constants will automatically be calculated by CivilFEM and sent to ANSYS.

V. Incentive Programs

The following ideas and strategies were provided regarding incentive programs:

- Include incentives for efficiency and for achieving milestones.
- Consider bonus incentives at the trade, foreman and management levels.
- Bonus schemes must be competitive across work groups.
- Some bonus/incentive system must filters right down to the worker. This means if a group working on installing lighting finishes on or under budget time, they should be rewarded.
- Performance based incentives targeting not just management, but more so on direct/trades persons.
- Recognition programs for work: quality, quantity, HSE, milestones. Awards/rewards for no lost time accidents.
- Negotiate with crews and provide incentives to complete work packages (WP) on time and quality without rework. As many WPs as they finish sooner directly relates to as much money as they make.
- Promote a healthy competition between crews in terms of safety and results by posting performance by crew in selected locations across the site (safety and performance by crew).
- Accountability of scope, time and cost. Maybe even a little bit of friendly competition.
- Care for employees is an incentive.This means the flexibility to meet workers needs, consistent with project needs.
- Monitor worker moral and watch for early warning for problems.
- Full access to comprehensive employee and family assistance programs. Reduce distractions of many kinds.
- Aggressively address undesired behaviour. Harassment is less of a human rights and safety concern, more of a performance killer. The Respect In The Workplace program is a good start.
- Implement incentive programs for construction contractors and engineering firm.
- Trades people, labour and all other associated workers should have bonus incentive clauses (today as in the past they try to make the project last as long as possible).
- Engage foremen with management and support them.

VI. Fire Protection By Taking Precautions In Building Construction

A building may be made more fire resistant by minimizing use of combustible materials, protecting steel by fire resistant paints and providing stairs at suitable positions and protecting them from fire. Various members of buildings can be made fire resistant as follows:

Walls:

Brick walls with cement plaster gives better fire resistance.

Roof:

R.C.C. flat roofs have good fire resistance. Hence they should be preferred.

Ceiling:
Ceilings should be made up of cement plaster, asbestos cement board or fibre boards.
Floors:
R.C.C. floor is very good fire resisting floor.
Doors and Window Openings:
All these openings should be protected against fire by taking the following precautions:
(*a*) The thickness of shutters should not be less than 40 mm.
(*b*) Instead of wooden, aluminium or steel shutters should be preferred. (*c*) They should be provided with fire proof paints.
Stairs:
Wood should be avoided in the stair cases. To minimize fire hazard, stairs should be centrally placed in the buildings so that people can approach them quickly. More than one stair case is always preferable. Emergency ladder should be provided in the building.
Structural Design:
It should be such that under worst situation, even if part of the structure collapses, it should be localised and alternate routes are available for escape.

VII. Conclusions

The findings of this pilot study conducted within the Alberta construction industry in the oil and gas sector is another example of the great need for the development of efficient and effective best practices to improve construction productivity. The prioritization of the 10 areas for improvement as assessed by industry professionals provides a framework and a guideline for productivity improvement on future projects. Future improvements as suggested by industry professionals can be summarized to include: Incentive and recognition program

- Transportation systems for people and large modules to remote sites
- Job-site access to workers
- Labour management and relations including working with unions
- Overtime and work schedule
- Training for supervisors and field personnel
- Front-end planning
- Workface planning
- Proper management of tools, equipment, health, scaffolding, safety, management of change, and rework, minimization, material management, quality management, contract administration, progress measurement.
- 80% engineering completion, 100% IFC drawings before construction.
- Supervision and leadership
- Communication
- Contractual strategy
- Constructability in engineering
- Pacing of projects
- Modularization, prefabrication, pre-build in shops
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- Our analysis of the industry survey findings shows that each of the stakeholders be they, the Owner, the EPC firm or Labour, has a role to play to achieve better productivity and to do a good job in performing their duties.

Owner's role may include doing a good job in leadership, engineering, scope, specifications, project requirements, staffing, managing change, contract and contractual arrangements, and communication. EPC firm role includes doing a good job in leadership, organization, communication, cost management, time management, safety management, material management, tools management, equipment management, access management, scaffold management, design management and setting priorities. EPC role also includes doing a good job in supervision and labour relations, subcontract work vs direct hire, work week, large job experience, work density, summer work vs. winter construction, skill of engineering, training, morale, bussing, camp, overtime, shift-work, turnover, rework, progress measurement, contingency plans and work face planning.

For labour on the other hand, their role is basically doing a good job in dealing with availability, absenteeism, continuity, skills and competence, supervision skill, supervision training, and supervision availability, jurisdiction, size of crew, waiting time, walking time, rework, weather, start, quit and break and communication. How good are we as stakeholders in fulfilling our roles and doing our jobs? This question must be answered by industry, because to improve construction productivity we must improve stakeholder performance in achieving their respective responsibilities. Improving construction productivity is not impossible and can be done. It takes commitment of stakeholders to overcome barriers to implementing the suggested ideas and lessons learned.

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