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White Paper

Efficient Communication Between Pipe Stress and Structural Engineers Using Hexagon Software

Pipe stress and structural engineers in offshore/onshore oil and gas, pharmaceutical, power, mining, nuclear and LNG have traditionally relied on a manual, paper-based process to communicate piping loads and support stiffnesses between the two departments.

These departments operate under tight schedules to produce the drawings and deliverables needed to order pipes, pour concrete foundations and fabricate steel structures. In recent years, the industry trend toward leaner workflows has companies looking for ways to improve interdepartmental communication to reduce duplication of effort and liability due to transcription and coordination errors.

Some firms attempt to develop in-house software, which is hard to maintain in a volatile industry with regularly changing design codes, software versions and manpower requirements. Others look to commercially available software, which typically has rigid workflows that don't meet the diverse project and company-preferred workflows and processes.

This paper will focus on a new LEAN workflow empowered by GT STRUDL® and CAESAR II® for engineering tasks and solutions such as Intergraph Smart® 3D and CADWorx® for plant modeling.

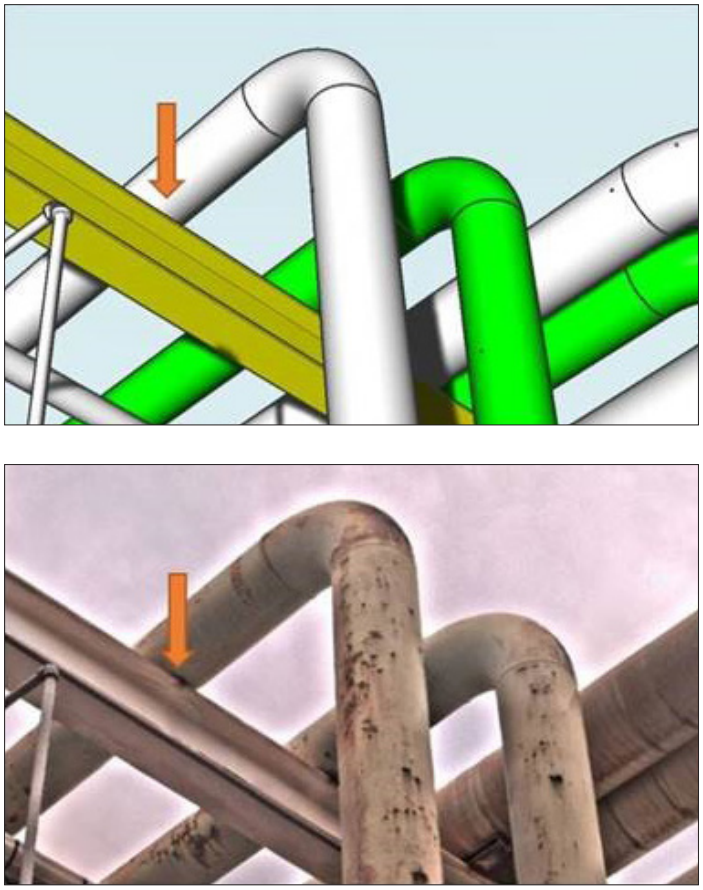
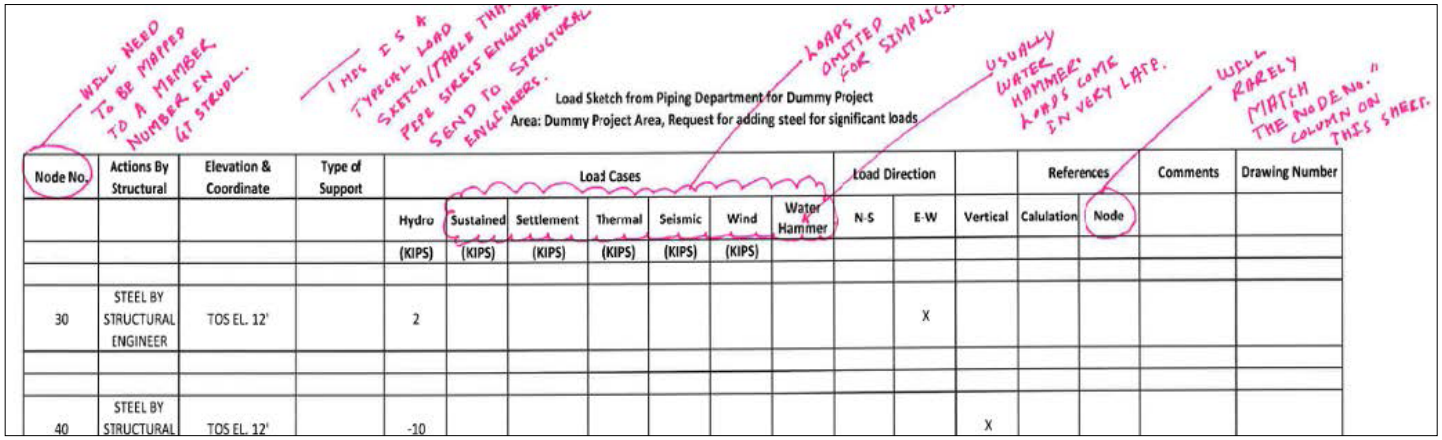


Figure 1: (Top) A model of a typical wide-flange structural beam supporting a pipe in CADWorx, which can be used to generate both the CAESAR II and GT STRUDL models. The beam needs to be designed to support pipe loads such as pipe dead load, content load, thermal load, wind load, etc. (Bottom) Site photograph of the piping and structural system.



Load Sketch from Piping Department for Dummy Project
Area: Dummy Project Area, Request for adding steel for significant loads

Node No.	Actions By Structural	Elevation & Coordinate	Type of Support	Load Cases							Load Direction			References		Comments	Drawing Number
				Hydro	Sustained	Settlement	Thermal	Seismic	Wind	Water Hammer	N-S	E-W	Vertical	Calulation	Node		
				(KIPS)	(KIPS)	(KIPS)	(KIPS)	(KIPS)	(KIPS)								
30	STEEL BY STRUCTURAL ENGINEER	TOS EL. 12'		2								X					
40	STEEL BY STRUCTURAL	TOS EL. 12'		-10									X				

Figure 2: A typical load sketch prepared by pipe stress engineers for structural engineers.

In a traditional engineering department workflow, the support loads obtained from CAESAR II are carefully copied (sometimes for up to six loads per node) and summarized on load sketches as shown in Figures 2 and 3.

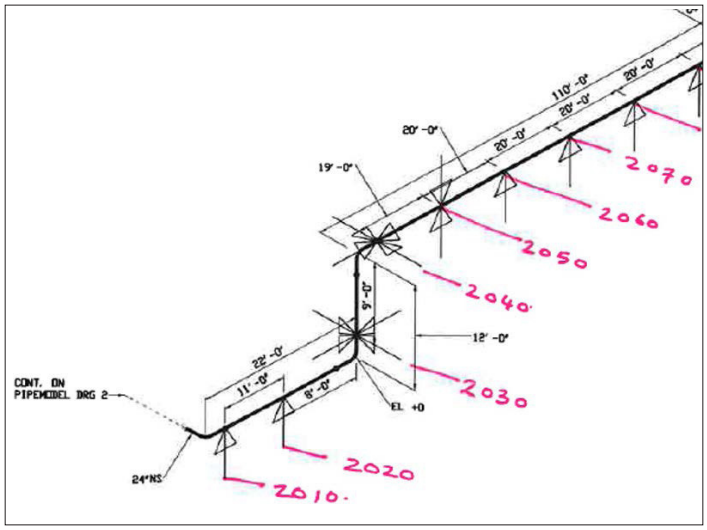


Figure 3: A piping isometric drawing with piping restraints hand marked.

These sketches are then given to the structural engineers who apply these loads to their structure as shown in Figure 4. Depending on company and project requirements, there may be multiple load cases per pipeline that need to be communicated to the structural department, meaning this process is repeated multiple times for each line.

```
 CASE: CASE 13 (OPE) WNC
 LCASE_NAME: DP
MEMBER LOADS
$ Reactions from CAESAR II node 1050 applied to member 219
 219 FORCE X GLOBAL CONC FRAC P  -178.596 L 0.4000
 219 FORCE Y GLOBAL CONC FRAC P    -6.727 L 0.4000
 219 FORCE Z GLOBAL CONC FRAC P -1928.572 L 0.4000
$ Reactions from CAESAR II node 1060 applied to member 214
 214 FORCE X GLOBAL CONC FRAC P    13.697 L 0.4000
```

Figure 4: Loads copied from a load sketch to structural analysis software. This data needs to be entered using the user interface or in STRUDL Language. The notes help engineering checkers verify if the loads were copied properly from the load sketches provided to the structural engineer.

After all of the appropriate loads are copied from the load sketches, they are checked by the engineer for accuracy. These loads are used in structural load combinations to design the supporting steel structures.

This process quickly becomes complex for typical pipe rack structures that have multiple levels and pipe runs. It also is time-consuming in today's iterative and fast-tracked projects. With any project, there is also a risk that later design changes may not be communicated or verified.

The structural engineering department is the last to receive all the information required to perform their analysis and is often the first to deliver Issued for Construction (IFC) drawings on a given project. While pipe stress and structural engineers are coordinating bracing locations, foundation engineers are facing a deadline to issue pile layout drawings or foundation drawings.

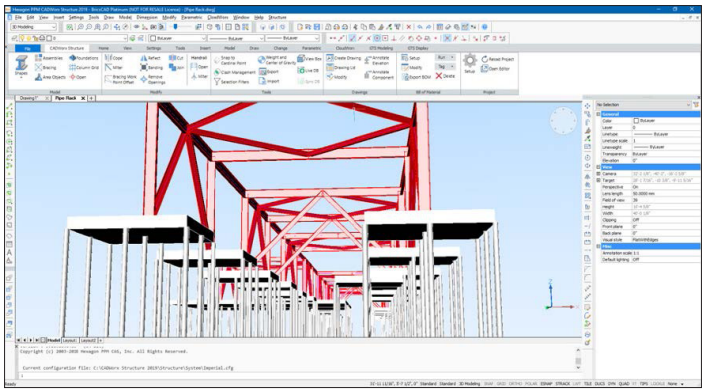


Figure 5: CADWorx Structure model can be exported to GT STRUDL directly using the gti export option.

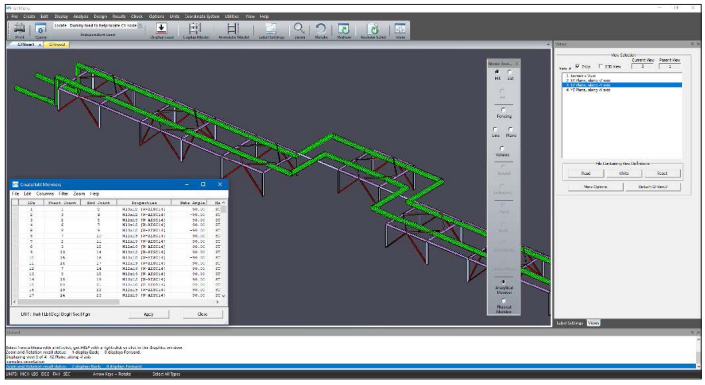


Figure 6: GT STRUDL Model created by CADWorx Structure. The piping model has been created using the CAESAR II analysis model. The piping model is not used during structural analysis. This feature allows structural engineers to verify if the piping and structural models are in the same coordinate space and verify the pipe restraint locations.

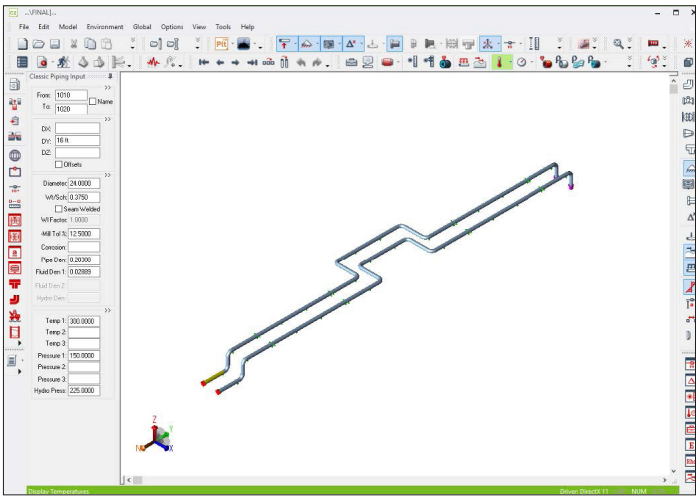


Figure 7: CAESAR II model can be imported from CADWorx Plant which will ensure that the piping and structural models are in the same coordinate space.

Delays in getting the information from one entity to another within the structural engineering department in this complex design environment has the potential to create a task-delayed ripple effect, which results in major delays and unnecessary conflicts between project scheduling, construction and client.

Some of the problems with the traditional manual workflow are:

- It is prone to errors due to transcription or location coordination
- It is very time-consuming for both the piping and structural departments
- It can delay projects where piping changes continue to occur late into the design cycle and effect beam, column or foundation design
- Changes to the piping system throughout the iterative project workflow resulting in changed support conditions or values may not be properly documented, communicated or vetted against the current structural design, introducing the risk of excessive piping or structural deflection or even failure during operations

These problems can be solved by leveraging the interoperability of Hexagon solutions to improve the speed and accuracy of communication between the piping and structural departments. The CAESAR II/GT STRUDL interoperability is flexible enough to support various workflows without creating rigid pre-conditions.

Case Study

On a given project, the structural engineer was required to obtain pipe restraint loadings from multiple pipe stress engineers. Leveraging the Hexagon interoperable solutions allowed the structural engineer to visualize the piping layout before importing the loads. Additionally, she was able to organize the loads in different input files per pipe run to manage any future changes to the restraint loadings.

When the pipe stress engineer was required to change the diameter of several pipe runs, these changes affected the dead and the wind loads that were previously provided to the structural engineer. The structural engineers had not anticipated that magnitude of change but were able to compare the new loads with the old loads easily and without a need to review other data that had not changed.

This allowed them to quickly provide an updated set of support reaction loadings to the connection detailers and foundation design engineers based on the new restraint loads.

Benefits for pipe stress engineers using CAESAR II:

- Eliminate the time required to produce load sketches and drawings as deliverables for the structural group
- Eliminate transcription errors in creating load stetches or ISOs
- Reduce coordination efforts of locating pipe runs and clarifying loads with structural department
- Quickly create and templatize standard load cases and/or combinations for the structural department
- Easily create results database to transfer load information, magnitude and location to the structural department
- Visualize and include the structural model in CAESAR II
- For critical pipe runs, easily import a GT STRUDL structural model or a part of the model to run a combined piping and structural analysis
- Allow multiple pipe stress engineers to work on different lines supported by one structure (a common workflow)

Benefits for structural engineers using GT STRUDL:

- Eliminate the time required to interpret, locate and coordinate piping sketches or ISOs to the structural model
- Eliminate the transcription errors in keying load location, magnitude, type and direction from paper to software
- Easily apply the Z-Axis-up rule to your model without running into any analysis issues
- Easily visualize piping run in relation to structure for conformation of geometry
- Visualize and retain CAESAR II restraint node mapping to GT STRUDL members in a table that can accommodate future changes and is compatible with MS Excel
- Leverage powerful search algorithms that allow the piping model and structural model centerlines to have an offset, which is very typical when modeling software such as Smart 3D or CADWorx is used to generate CAESAR II or GT STRUDL models
- Maintain control over which piping load combinations are imported
- Quickly import loads to GT STRUDL
- Automatic documentation of loads inside loading input file in editable text format
- Implement common workflows such as rounding loads up to accommodate any expected future changes
- Apply pipe loads on the structural members without creating extra nodes on the members; the creation of extra nodes effects the design parameters and increases run times and complexity of results reviewing
- Automated comparison and verification of load changes during iterative design process

The return on investment for this LEAN workflow is clear. For a small structure with 25 restraints and 10 primary load cases, this manual process would consume 16 work-hours in each department. GT STRUDL's interoperability with CAESAR II can reduce the work-hours required to transfer piping loads from four different pipe stress engineers to the structural department down from 16 hours to just six minutes. Both departments save additional time each time the pipe restraint loads change.

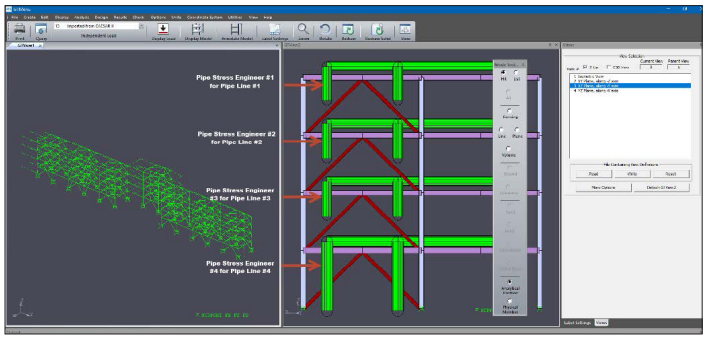


Figure 8: Multiple CAESAR II piping models created by different pipe stress engineers imported into GT STRUDL in a matter of minutes.

Conclusion

Why use CAESAR II and GT STRUDL interoperability for your next structure and piping project?

Among many reasons, the top ones for the plant industry to adopt this new technology are:

1. **Double your team efficiency:** As shown, this interoperable workflow can increase your team velocity up to 40% compared to the traditional manual process.

2. **Digital transformation:** Stacks of load sketches are replaced by digital information flow that is easily extensible to common formats like MS Excel for error checking or other project stakeholders to leverage. Data control is retained by the engineer to meet varying project requirements and workflows.

3. **Change visibility:** View changes in pipe restraint loads faster and with trusted accurately. Issues can also be resolved at the engineering level rather than channeling them through the design department.

4. **Respond to changes faster:** Because of the efficiency offered by this integration, projects can now perform changes quickly and see how these changes will affect disciplines such as process, piping, structure and foundation.

For more than 40 years, GT STRUDL has offered structural engineers a complete design solution and is known for its power and ability to handle challenging projects. Test the interoperable workflow discussed here risk-free today with free datasets and training videos from our Smart Support platform!

About Hexagon

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Hexagon's PPM division empowers its clients to transform unstructured information into a smart digital asset to visualize, build and manage structures and facilities of all complexities, ensuring safe and efficient operation throughout the entire lifecycle.

Hexagon (Nasdaq Stockholm: HEXA B) has approximately 21,000 employees in 50 countries and net sales of approximately 3.8bn EUR. Learn more at hexagon.com and follow us @HexagonAB.