Intelligent Engineering Service

In 2015, CTCI created a new scenario by delivering an array of achievements in intelligent engineering services. These inspiring breakthroughs, including technology/expertise improvement and work automation, have been extensively applied to our worldwide EPC undertakings and garnered substantial outcomes.

In 2016, CTCI keeps up its efforts to enhance core design capability and improve the efficiency of project execution through continuous research and development in expansion for the breadth and depth of engineering management and technologies/expertise. To create competitive differentiation and advantage, development of iEPC (Intelligent EPC) is ongoing to shift the manner of EPC operation “batch processing” to “micro-segmentation processing”, so that each design modification can be supervised in real time, allowing all operations to be fully integrated and effectively managed. For technology expertise, we have been developing the risk assessment and analysis of lightning protection, Reliability, Availability and Maintainability (RAM) program, the analysis and application on the swelling vitreous pearly particle of pitchstone, and the application of QR code/RFID in construction engineering. In the meantime, our internal design guidelines and existing engineering software have been revised according to the updated code/standard and other information collected for engineering practices from domestic or abroad.

In the near future, more efforts will be made on micro-segmentation processing developments to enhance our capability in project management, boost our competitiveness, and distance ourselves from our competitors; hence we will move closer towards our vision of being known as the most reliable global engineering service provider.

2015 Innovation Service Achievement

I. Technology/Expertise Improvement

Development of Failure Mode Effect Analysis and Critical Analysis (FMEA/CA)

The development of FMEA/CA is to build CTCI's core technique for process safety team. Benefits of developing FMEA program include: (1) integration of the best practices, methodology, and the hands-on experience, (2) establishment of CTCI's Working Instruction for FMEA/CA, and (3) improvement of skills for FMEA/CA workshop.

Basic Design for Membrane Technology of Zero Liquid Discharge Systems

Zero Liquid Discharge (ZLD) systems employ the most advanced wastewater treatment technologies to purify and recycle virtually all of the wastewater produced. Currently, membrane technology is the most cost-effective in ZLD systems. Based on relevant literatures and engineering standards, CTCI had accomplished the research of process parameters and system design of membrane technology in ZLD application. With the completion of this research, CTCI has equipped itself with the capability of basic design for this process.

Design of RC Pier with an Embedded Steel Column

The base of steel columns in a plant building structure is required to fix in the reinforced concrete (RC) support or the foundation. In general, steel column base welded to a base plate is fixed to the RC foundation using anchor bolts when the column size is relatively small. However, the strength of base plates will not be able to effectively transfer the loads to the RC supports or foundations when columns with a rather big cross section are subjected to pretty high load effects. A common solution for this problem is to embed the steel column with welded shear studs into the RC pier. The application of shear connectors helps to gradually transfer steel column loads into the RC pier, then from pier into the RC foundation. Currently, the mechanism of load paths or stresses is not yet clear and thus the design method tends to be conservative. This can be seen

from an example of engineering practice that the congested shear studs in the portion of steel column embedded in RC pier (as shown in Figure 1), and that the pier height or the embedded length is quite long and the amount of reinforcing bars used are tremendous (as well illustrated in Figure 2). Now, with the mechanism of load transfer path between the steel column and the embedding RC pier, a more accurate analysis and design method can be derived. The method has been verified accurately by actual specimens in lab experiments of structural mechanics. Through the development of foregoing technique, CTCI enhances the capability of the steel structural design, and makes a concrete contribution to engineering practice.

Figure 1 Steel Column Construction

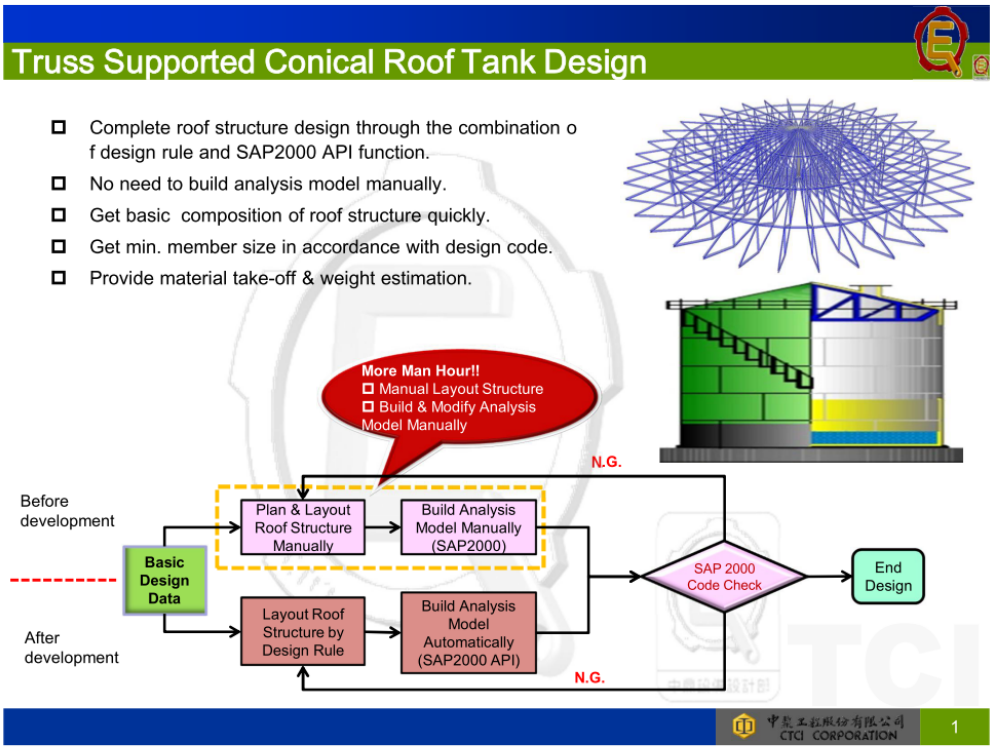
Figure 2 RC Pier with an Embedded Steel Column

Truss Supported Conical Roof Tank Design

Column supported roof is widely used in the design of large diameter tank. The existence of support column will cause the emission of the content and affect the operation of internal floating roof. To solve these problems, truss structure can be adopted as an alternative solution because of its features of no support column, simple member, light weight, and easy to assemble into different shape, etc.

However, most commercial storage tank design software can't deal with truss-support conical roof design. Therefore, commercial steel structure software has to be used to perform the design. This approach requires skillful steel design software users and if necessary, a lot of man-hours are needed to repeatedly modify the model in order to meet code requirements.

In view of this, CTCI refers to existing design cases and design standards, analyzes and collates into a design rule-based module, and integrated with the SAP2000 Open Application Programming Interfaces (OAPI) component to develop Truss Supported Conical Roof Tank design program, which not only can quickly yield reasonable design result, but also provide material take-off and weight calculation in order to facilitate cost estimates.



Truss Supported Conical Roof Tank Design

Piping Pulsation and Vibration Analysis of Reciprocating Compressor

Due to the regular inlet and discharge character of reciprocating compressor in refinery and petrochemical plant, the pulsation in piping system is the major cause to induce piping vibration. Therefore, via a cooperative research project with National Taipei University of Technology (Taipei Tech), we studied the practical case of piping system of reciprocating compressor. Using Taipei Tech's specialty and related resources of software, we delved into the theory of piping pulsation and vibration, established a feasible analysis method and standard procedure, enhanced our ability to verify the analysis report equipment vendor provided, strengthened the design quality of piping system of reciprocating compressor, and hence avoided the problems of piping vibration during operation.

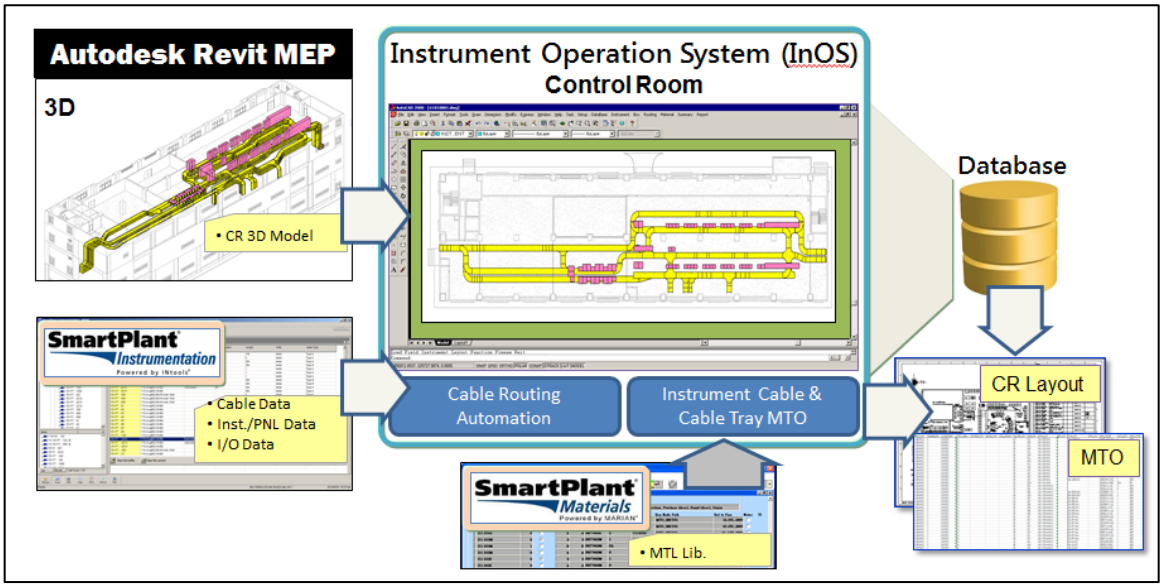
Cathodic Protection Application for Offshore Structure and Facility

Cathodic protection is a corrosion control technology, which had been widely used and applied to metal structure. However, cathodic protection technology in the seawater has still been under development to meet the needs of offshore EPC projects according to the specific structure and facility. Based on NACE released papers, CTCI has analyzed the seawater corrosion characteristic and factors, collected the suitable anode materials, and developed the calculation program of cathodic protection system to simplify the complex calculation and procedures users have to deal with, reduce human error, and improve working efficiency.

II. Work Automation

Automatic Design for Instrumentation Control Room Layout

3D visualization has been applied to Instrumentation Control Room design. We



utilize Revit 3D to execute the design of the control panel arrangement and cable tray path, then upload the 3D modeling and information into the Instrument Operation System (InOS) of instrumentation, to integrate with the cable data of SmartPlant Instrumentation (SPI) and the cable specification of SmartPlant Material (SPMat). After that, we use the automation programs of InOS to conduct cable routing and cable/cable tray material take-off, and finally produce Control Room Arrangement Drawing, Cable Tray Layout, Wiring Layout...etc.

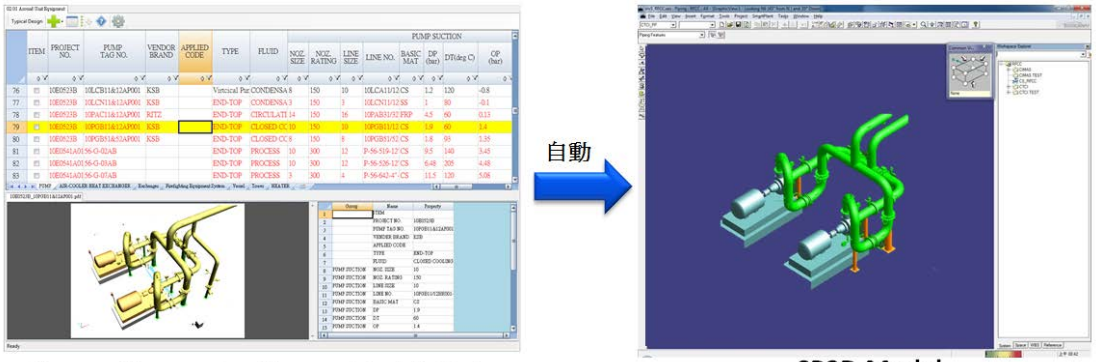
By conducting design directly in the 3D system, integrating 3D and 2D system, and operating automatic programs, we are now able to ensure the consistency of 3D and 2D design and improve working efficiency. Also, due to the digitalization of design information, we can integrate more systems, and maximize their effects in the future.

Automatic Design Workflow for Instrumentation Control Room Layout

The Automatic Modeling of Typical Piping around Unit Equipment

During 3D modeling stage of an EPC project, a well-established database of 3D piping design module around unit equipment can assist piping engineers to

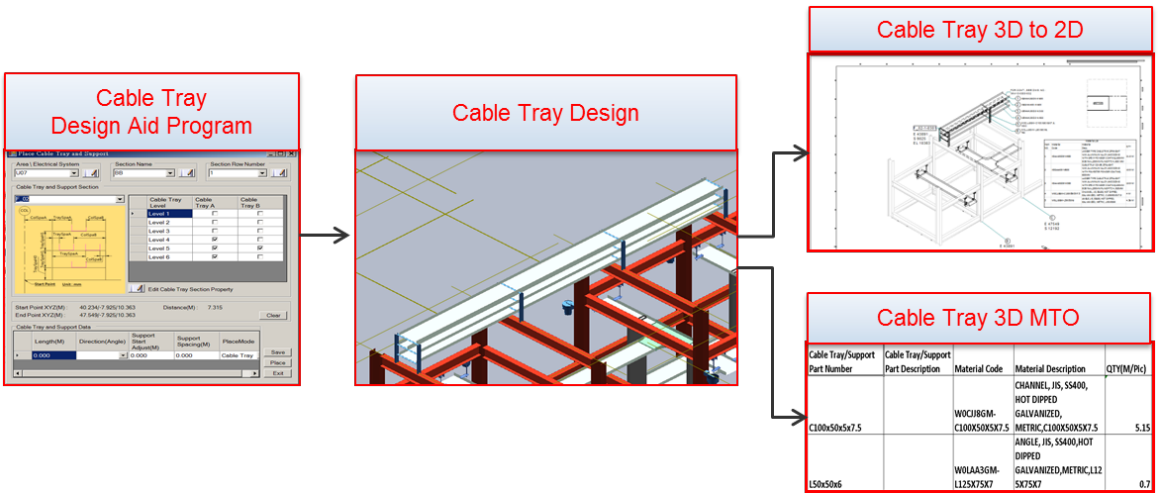
select the optimized typical piping design model based on process condition such as equipment type, pipe size, operation temperature and pressure, and to place the model in the SmartPlant 3D platform automatically for piping engineers to perform the necessary modification according to process requirements. This application can help to reduce design time and improve design quality.



The Automatic Modeling Workflow of Typical Piping around Unit Equipment

Cable Tray Program Aided Design

The purpose of developing cable tray program aided design is to change the traditional 2D design into automatic design integrated with 2D, 3D, and back-end material database in order to achieve the goal of data sharing, full data transfer, and data consistency, and enhance the design efficiency and quality. CTCI has



applied this program to EPC projects successfully.

Cable Tray Program Aided Design Workflow

Developments in 2016

I. Intelligent EPC (iEPC)

In order to keep up with the trend of EPC turnkey service, as well as to cope with the impact of population aging and declining birth rates, CTCI incorporates the concept of Industry 4.0 into innovative EPC management. With the planning of iEPC, management of design change will be shifted from "batch processing" to "micro-segmentation processing", so that any changes in technical data, specification and so on could be dealt with in real time, resulting in refined management and more competitive differentiation.

To achieve these goals, CTCI sets three aspects of iEPC:

1. Construct the Tag Platform with the life cycle of engineering objects in order to integrate the data of engineering, procurement, construction and commissioning, such as 3D models, equipment requisition QTO. It can develop an engineering information chain for the whole project to achieve the integration purpose, and serve as the basis for big data analysis and machine learning in the future.
2. Based on the requirements of project micro-segmentation management, data from inter-disciplines will be consolidated with Tag Platform. Data could be passed rapidly to both downstream and upstream by methods of Publish / Extract / Transfer / Load / Retrieve to shorten the timespan of project.
3. Leverage productivity by promoting design automation programs in every department to assist engineers with their works, such as intelligent pipeline design, automatic selection of instrument control valves, automatic layout of power line, and automatic selection of section for steel structure.

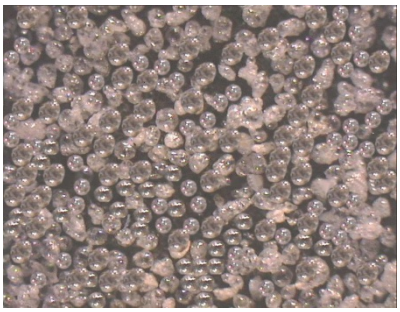
II. Technology/Expertise Application

The Risk Assessment and Analysis of Lightning Protection

For the requirement of minimizing the impact of lightning, selecting the suitable protection facility is necessary. IEC 62305 specified the appropriate design, installation and maintenance of lightning protection regarding to the lightning protection for the building structure, prevent personal injury and failure of electrical/electronic systems. IEC 62305 also determined the requirement, economical efficiency, and appropriateness of the lightning protection facilities based on risk assessment. The researching result can be applied to the future industrial infrastructure and petrochemical plants projects, as well as enhance lightning protection professional technology, risk assessment, and analysis abilities.

Analysis and Application on the Swelling Vitreous Pearly Particle of Pitchstone

The swelling vitreous pearly particle is mainly used for a light material mixed with sand mortar to constitute the heat insulated fireproof material. Because of its characteristics of low water absorption, minor shrinkage rate, lesser tendency to form void fragments, and having stable features of thermal and mechanical property, the mixed mortar usually has a prolonged service life. Moreover, compared with the light grains mixed in the conventional mortar, the swelling vitreous pearly particles are able to develop good construction property of fluid workable mobility and that of high water retention. CTCI is embarking an in-depth research to probe and analyze the feature influence to the detail proportion design for this kind of lightweight concrete, and then employs it to the project applications for further enhancing CTCI’s competitive edge.



The image of swelling vitreous pearly particle

Development Program of Reliability, Availability and Maintainability (RAM)

In recent years, there have been more clients of mega projects requesting EPC contractors to assist them in quantifying the performance of their asset by developing a RAM model.

The concepts of RAM:

1. The construction and operation of a process asset involves large capital expenses as well as operation expenses.
2. The commercial return of these assets is dependent on the RAM of the systems and components within the asset.
3. The ability to predict future performance of the asset using past and existing performance information of similar facilities allows the asset to achieve its maximum performance.

The Application of QR Code/RFID in Construction Engineering

Both QR Code and RFID have benefits of mobility and quick response. To make sure every construction work uses the latest drawing version, CTCI has applied QR Code technology to control ISO drawings on site. Also, QR Code has been used to manage pipe spool pre-fabrication in fabrication shops and automatically report the completion rate of the work as well. In addition, RFID has been applied to the entry access control at construction site. In the future, CTCI will apply QR

Code and RFID to inventory management of equipment to save time and manpower. We also consider applying QR Code and RFID to the asset management of critical equipment and machinery. All these help CTCI to improve productivity and competitiveness.