Practical Considerations Related to New Trends and Developments in Contracting, Financing and Delivering Underground Infrastructure Projects

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1. Introduction

The demand for developing the necessary infrastructure to release the stresses of worldwide urbanization has become one of the most important challenges of the 21st century. For large-scale development of urban infrastructure in underground space, the following essential conditions are necessary:

- visionary planning and design concepts,
- well-prepared professional organizations for implementing projects by innovative techniques, adequate capacity and equipment
- sufficient capital for financing
- efficient and balanced contract practices providing framework for collaboration and mutual benefits for all stakeholders involved in successful project completion

Since its foundation, the actions and publications of ITA have had beneficial contributions to awareness of visionary planning of underground space, attracting capital towards infrastructure financing, and developments in construction techniques and contractual practices as well.

By presenting some up-to-date practical considerations regarding recent developments in financing, contracting and delivering large infrastructure projects, the authors also intend to contribute to this progress.

2. Impacts of global crisis on project financing, planning and construction

2.1 Global crisis - trends and challenges of the world economy

The financial crisis started in the United States and the subsequent economical recession became evident worldwide in September 2008. The various geographical regions from North America, Europe to Asia have been affected in different ways and levels. The crisis raised many questions about the regulation of financial markets, the value of globalization, the sustainability of growth and energy consumption, insufficient infrastructure in urban centres and so on.

2.2 Impacts of the crisis on the construction industry

As a first impact of the crisis, stocks have fallen, banks have failed, private project financing have been radically slashed, hence construction projects were delayed or cancelled and bailouts have come. Most sectors of the construction industry have been facing their most severe downturn in more than twenty-five years.

Over the first year, the construction companies have responded by cutting costs, reducing investments and headcounts, and making cautious short-term plans only. They braced themselves for a roller-coaster environment. Shortage of work has boosted competition and pushed prices down nearly everywhere. In
North America, the selling cost of construction went down more than 10% on a year-over-year basis. This is the largest drop in costs for a given year since the 1930s. About a year after the global economy nearly collapsed, construction companies have started to mix short- and long-term initiatives. Those included cutting costs, exploring new markets, restructuring to ensure that their organizations are flexible enough for responding to the very competitive environment and challenges of the global economy.

Today most of the economists predict that construction, one of the driving sectors of the global markets, after a significant recession in 2009 will slowly resume in the longer run. In five years from now, governments will be more involved in the economy as a whole, the financial sector will continue to see increased regulatory constraints and the construction industry will be stronger and consolidated - but will grow more slowly than before September 2008. The recipe for coming-out is strategic planning, focusing on innovations, flexibility, new markets and preserving competitive position. The adaptation of new technologies is more important to growth than it was before the crisis.

2.3 Impact on financing of construction and infrastructure projects

2.3.1 Private sector financing
As a result of the economic crisis, banks, developers and investors have stopped financing new construction projects at an unprecedented rate and tried to slow down or discontinue ongoing construction of private residential, commercial, industrial and infrastructural projects. They became justly concerned about the uncertainties of the economy. Numerous financial institutions have failed, and the media were filled with catastrophic news and bankruptcies. Availability of financing for new projects became very limited or none existent.

2.3.2 Government stimulus packages
Many governments worldwide had to step in and create some kind of recovery plan to stimulate their economy in the recession. In addition to the direct bailout of certain critical industries, the lion share of funds dedicated to these plans has been directed to governmental and infrastructural projects. The effective implementation of the plans has required focus on awarding, managing and overseeing the grants and contracts.

As an example, in the United States after the administration approved the funds for recovery, the Office of Management and Budget issued guidance to agencies for administering stimulus funds, providing the requirements on financial reporting, risk management and contracting. They regularly submit spending and performance data to recovery.gov, a public website that provides information on how the stimulus funds are spent. The agencies accurately track, monitor and report on progress of works and spending of taxpayers’ funds. Its purpose is to allow citizens to hold the government accountable for every dollar spent.

In the crisis, only countries with strong economies could have afforded to create massive recovery plans, using their reserves or accept the consequences of deficit for years to come. The position of countries with frail economy worsened. Instead of stimulating recovery, many of them needed external funds to avoid economic failure. Several Asian, African, East European governments turned to the IMF and they have been forced to follow a shortsighted policy to balance the deficit from the loan received. Their economical and social status deteriorated, the GDP plunged and the unemployment rates have skyrocketed.

2.4 Impacts on capacities of infrastructure projects
The fact that one of the primary targets of the government recovery funds has been the improvement of transportation, communication, energy, urban and social infrastructure, provided a special situation for a section of construction industry.

Construction companies engaged in infrastructure work have been in a better position to maintain or consolidate their status and capacity than contractors in other segments of the market. As the recession has deepened, more and more construction companies have turned towards the market of infrastructure projects from the overcrowded and slow commercial, industrial and residential market. It has boosted the
competitiveness and expanded the construction capacity for large infrastructure works. On the other hand, it has jeopardized the quality and success of some challenging projects due to a lack of required experience, technique and equipment of the newcomers.

2.5 Developments in North America and on the Global Market
The crisis started in the United States, and economists in North America have consistently indicated that it would end sooner there than elsewhere. The economists in the Euro zone have always been more pessimistic about their economic situation and outlook. However, the pattern of problems and expectations has been essentially the same in all these regions.
The government of the USA is allocating about $1 billion per day to contracts, grants and loans. The Canadian government’s recovery plan has also started to boost the economy. North America expects to see slow construction growth for 2010. However, the outlook for construction loans for commercial projects across Canada and the U.S. continues to deteriorate.
Several economists around the world - and mainly of those in Asia’s developed economies - say that an economic upturn has already begun in 2009. In the past after a global recession, the United States led the way out, followed by Europe and the rest of the world. Now, for the first time, the driving force is coming from China and the rest of developed economies in Asia.

3. Technological advancements improving construction processes

3.1 Major areas of recent innovations
As the construction industry responds to the challenges of a changing economy, the move towards innovations and advanced technologies will become significantly more important to improve the companies’ market position. Major areas of improvements that will alter the industry over the next five years and keep companies in leading-edge position:
- Flexible strategic planning to respond to the changes of global economy
- Introducing BIM, three-dimensional design modeling and information system
- Optimized life-cycle project management technologies integrated with BIM

3.2 Strategic planning for adapting to the changes of global market
“It is not the strongest or smartest who survive, but those who are most adaptive to change” Charles Robert Darwin (1809 – 1882)
Construction companies have been anticipating uncertainty of the market and the economy. However, many of them still have not adapted any new way to develop a corporate strategy dealing with the impacts. Here is a list of advice from Professor Paul J. H. Shoemaker [‘Profiting from Uncertainty’ - Amazon 2002] for the best practices companies should follow.
- Use scenario planning to improve your organization’s foresight about the future
- Adaptive strategies that have sufficient flexibility built in to deal with the unexpected,
- Design a dynamic monitoring system to track the external world, as well as the internal progress of executing strategies and plans
- Improve your organization’s agility in terms of structure, processes and rewards to cope better with the unknown
- Enhance your information and decision-making procedures to remain vigilant through external networks and by properly balancing traditional tools and new technologies
- Foster strong leadership at multiple levels in the organization to deal better with crises and other unexpected circumstances

3.3 Three-dimensional design modeling and information system
Based on recent innovative technological developments, a brilliant new technology came along that enables rapid innovation and change in construction. **BIM = Building (an) Information Model** - is an innovative methodology for three-dimensional modeling, generating and managing data. It encompasses all data associated with the design of a building, a structure or any system, including geometry and spatial relationship, as well as quantities and properties of system components.
The basic types of software to accommodate the needs of various disciplines:
• **Architectural BIM** - It captures the geometry of walls, foundations, frames, roofs, and window systems of a building and the properties of the building elements (glass properties, typical insulation values, etc.) Most BIM tools also include visualization capabilities for realistic rendering of projects.

• **Structural BIM** - It captures the detailed design and modeling of structures, and structural elements of foundations, walls, columns, beams, slabs, supports, and trusses along with live and dead loads for all the elements - to qualify the building structure for load compliance.

• **Mechanical and electrical BIM** - It extends the BIM analysis to all building service systems, and design of pipes, ducts, conduits and equipment required.

Once the building model is completed in 3D, 2D prints are also available from the model. They can be drawings of rendering, plans, elevations, cross sections and details. There are several special systems developed to expand interoperability between the portfolios of architectural, engineering and construction software.

In the planning phase, BIM encompasses conceptual, iterative, and final detailed design. In the construction phase, BIM provides a number of valuable analytic information and practical supports, view and models for site access, hoisting, construction methods and logistics, soil and rock formations, clash detection and so on.

Then it leads into the operating and maintenance phase with as-built models, as-built equipment and the model of completed virtual facility. Numerous software developers have many products to serve the needs of the construction industry. More and more architects, engineering and construction firms are using BIM software systems to complete their project assignments. It is expected that within 2-5 years BIM will have widespread use by the industry stakeholders.

### 3.4 Application of 3D modeling in infrastructure construction

No special software is required for preparing models to visualize underground structures, topography, soil/rock formations and layers. Most of the BIM type software can create three-dimensional model of the designed elements for tunnels or complex underground structures. In addition, using the detailed soil and groundwater information from borehole logs and interpolation between those can provide a three-dimensional stratigraphy of soil and rock environment. This can be very useful for planning various construction activities and methods for subsurface operations.

There are software applications available for 3D modeling and soil analysis for earthwork geometry and profiles. These systems can provide analytical design of soil behaviours and structural movements applying finite elements or similar numerical methods of calculations. Adding new dimensions (the time and the cost) for the 3D model are frequently used options in construction. The 4D model is visualizing the construction progress in time on the changing model. The 5D models are using cost loaded elements and creating budgets, cost estimates or cash flow analysis.

### 3.5 Life-cycle management of infrastructure projects integrated with BIM technology

Few projects are as complex and have as long a life cycle as infrastructure projects. Tunnels, bridges, water treatment plants, airports require the coordination of countless participants, activities, processes, requirements, reports and data, to keep them organized and available during the functional life of the facility.

In the past, the capital project was managed in three separate stages, with different stakeholders: planning – building – operating. The stakeholders would pass only the specified minimum of information from one team to the next, because of conflicting interests, data incompatibility and timing. The increasing complexity of global infrastructure has forced the industry to re-think and re-structure the project management and documentation from inception to completion incorporating innovative techniques, like the building information modeling. The trend in BIM software is moving toward distributed building information models compatible to highly specialized management software tools.

For interested general contractors or various construction organizations, several innovative systems and software packages are available to automate the process for optimizing and managing complex infrastructure projects and integrating multiple, cost-loaded BIM models. The focus is on collaboration, document management, planning, budgeting, financing, purchasing, progress and cost tracking, plus ongoing maintenance and re-development as required.
4. New trends in project delivery methods for complex infrastructure projects

4.1 Traditional project delivery methods and contracts
Frequently used project delivery methods are the Bid–Build (BB), Design–Build (DB), Design-Build–Operate (DBO), Design-Build-Operate-Financed (DBOF), Build-Own-Operate (BOO), Build-Own-Operate-Transfer (BOOT), Construction Management (CM), and CM with Risk (CMR) contracts. Some of these can be delivered with Guaranteed Maximum Price (GMP) option, or in (JV) version, when the contractors form Joint Venture Partnership. The contracts are governed by international (FIDIC), national or regional recommendations combined with impacts of local law. All of the presented delivery methods are based on two party contracts between both the Owner-Consultant and Owner-Contractor, sometimes between the Contractor-Consultants. With the presented delivery methods, the Contractor takes most of the financial, legal and technical risks and responsibilities for the success of the project. It can often lead to hardship, distrust, adverse relationship and lack of collaboration between the contracting parties.

4.2 Motivation of improving collaboration in project delivery
The idea of securing better collaboration between the major stakeholders involved in the project has emerged a long time ago. At first, the introduction of Partnering workshops targeted the collaboration elements at traditional two-party contract environment. After that, the collaboration and the idea of balanced risk/gain sharing became the driving force in the multi-party legal agreements between the major project team members in the Incentive or Alliance contracts. Recently the new Integrated Project Delivery contracts extended this by integrating high-tech project and document management with advanced 3D modeling system to the process.

4.3 Doorstep to collaboration: Partnering
Partnering is about improved relationships. It enhances the collaboration by improving communication, trust and fair dealing between project team members using traditional two-party contract between Owner-Contractor. The partnering arrangement is usually implemented through Partnering Workshop, held soon after the contract is signed and senior managers and site staffs from contractors, subcontractors, consultants and suppliers attend.

4.4 Collaboration and incentives in recent contracts and delivery methods
The concept of Alliance contracting in construction has two groups of conditions. The first group contains hard contractual terms, the formal contract, real gain-sharing/pain-sharing incentives. The second group contains soft, relationship-based conditions, like trust, long-term commitment, cooperation and communication. A number of additional elements can also be included to constitute a specific variation of Alliance contract.

The basic idea is that if each participant works in a risk-sharing environment for achieving outstanding project outcomes, it will lead to increasing levels of financial gains. In other words, everyone wins. The contribution will be through effective project management by all parties; problems will be recognized early and resolved amicably. The result is that the project is successfully completed within cost and time.

4.5 Technology advancements integrated in a new project delivery method
Recent technology advancements provided the foundation for a new delivery method. Integrated project delivery system - IPD is a new approach to management processes for design and build operations, accommodating intense intellectual collaboration and innovative design modeling that 21st century complex constructions require. The idea of IPD is based on collaborating relationship of project team with a mutual responsibility to help each other to meet a common goal.

The first important step is selecting the principal parties involved in the project delivery as early as possible - ideally at the conceptual design stage. It would provide a collective expertise to the project development before anything is designed. The ‘shared risk - shared reward’ contracts shall also be established upfront. Contract terms and management processes intended to harmonize the interests of the project team members with the project mission: increase efficiency, reduce waste, and make the best result.

‘Shared risk - shared reward’ means that if a problem comes up on a project, the focus of the team is on finding a solution rather than assigning blame for the problem. It eliminates much defensive
documentation causing adversarial relationships and transforms the focus of the parties from protecting themselves to solving problems and getting the project done.

IPD projects usually have eight characterizing common items: legal relationship; a management committee; an incentive pool; no-blame working environment; BIM design assistance; collaboration software; best constructability; and integrated leadership.

The practical operation of IPD relies on the use of applications associated with building information modeling system. BIM produces integrated models and drawings. It allows the team to build virtually before building physically, to catch and resolve problems in the modeling stage, and to make many value-added decisions much earlier in the process with greater confidence.

The improved documentation and project management systems are designed to organize, search and access all electronic project information including text, drawings and BIM model files in a unified database during the whole life of the project. The systems enable bi-directional flow between the BIM model and project management. When models are modified, the associated budget, costs, and effect on the project’s schedule can be up-dated and managed through the automated systems.

5. Impacts of consensus-based and onerous contract conditions

5.1 Contract conditions with positive impacts

Typical contract forms and general conditions, established by organizations of industry stakeholders are based on consensus and balanced risk-sharing concept.

Supplementary Conditions of Contracts usually include terms that are specific to the project. Most of those can be very useful, when clarifying processes, commercial, legal and technical requirements, parameters. They can assist to avoid future problems and disputes. For example, the Owner may order, purchase or pre-select items to a specific infrastructure project prior to the selection of Contractor. It can decrease the schedule related risk and/ or assure the quality and compatibility required by the project. With infrastructure type construction the most crucial products (special equipment, instruments, cables, pipes, TBM’s, liners etc) can be subject to this procedure. This is a prudent practice and it can enhance the risk sharing between the parties.

5.2 Contract conditions with negative impacts

However, some supplementary conditions – often triggered by poor legal advice to Owners – intend to download serious or unknown risks and put unnecessary financial burden on the Contractors, or tighten the control on them by limiting their options. Those onerous conditions create unnecessary adversarial relationships and distrust between the parties before the project starts, and may increase the price as well.

On complex infrastructure projects, experienced contractors stay away from any tender or contract with onerous conditions and unbalanced risks, or they build large contingency into their price.

6. Conclusion

Welcome to the new world of construction.

After the global crisis, infrastructure-related construction companies are certainly going through a cultural, economical, technological and environmental change – like the whole construction industry does. To improve their competitive position and growth, all stakeholders shall adapt innovative technologies, improve collaboration and reduce risk.

Major improvements can be achieved through flexible strategic planning, embracing and getting the highest value out of the revolutionary three-dimensional modeling technologies and combining them with highly specialized software tools for optimized collaboration, project and document management.

Companies with solid core expertise, equipped and proficient with these innovative techniques can also be successful in participating in various collaboration-based integrated project delivery methods - in the new world of construction.