APPLIED FAST TRACK APPROACH IN TUNNEL DESIGN: LESSONS LEARNT

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ABSTRACT

When time constraints in tunnel construction cause standard design and construction procedures to be compressed and time sensitive decisions are critical, preceding over other conventional requirements or when tunnel construction commences prior to the completion of all final design documents, then a Fast Track approach in tunnel design is an attractive solution to move the construction forward, satisfying the strong need for construction kick-off and enabling discrete design processes to run in parallel. The Fast Track approach is based on clear chain of commands between the Contractor and the Designer. Very few decision making individuals, clearly designated by both parties are authorized, trying to avoid insignificant changes when decisions are made, to keep a well thought out program of requirements and a very close contact. Very strict control and quality assurance of the construction activities is performed, constant interaction with the Client is maintained and effort to avoid design processing delays for minor modifications is kept. The recent application of the Fast Track design approach in several major tunnel construction projects is presented, with special focus on the administrative and managerial problems usually encountered and the main construction achievements gained. The main lessons learnt by Clients, Contractors and Designers are analysed and the key points for optimizing the Fast Track approach in the future are identified.

1 CHOOSING TUNNEL DESIGN DEVELOPMENT METHOD

An Owner or a Contractor embarking on a construction project must make an important decision regarding the method by which the project is designed and constructed. This decision has become more difficult in recent years as several alternative methods have been developed to address weaknesses in the traditional design-bid-build scenarios. (Fig. 1) Methods that have gained in popularity include at-risk design and construction management, fast-track construction, multiple prime Contractors, and design-build. Proponents of particular alternative methods promise improvements over the traditional system in terms of cost, project control and reduction in disputes. (CMAA, 2012)

For the Owner or the Contractor, the plethora of choices can be both good and bad. The downside is that with the variety of project delivery systems confusion can be inevitable. The good news is that the increased number of alternatives, offers more flexibility to choose an appropriate and effective system for each particular infrastructure project.

Among the main disadvantages of the traditional system are:

1. The process is time-consuming since all design work must be completed prior to solicitation of the construction contract.
2. The Designer may have limited ability to assess scheduling and cost ramifications as the design is developed which can lead to a more costly final product.

3. The Owner generally faces exposure to Contractor claims over design and constructability issues since the Owner accepts liability for design in its contract with the Contractor.
4. The traditional approach tends to promote more adversarial relationships rather than cooperation or coordination among the Contractor, the Designer and the Owner.
5. The Contractor pursues a least-cost approach to completing the project, requiring increased oversight and quality review by the Owner.
6. The absence of a Contractor's input into the project design may limit the effectiveness and constructability of the design. Important design decisions affecting both the types of materials specified and the means of construction may be made without full consideration of a construction perspective.

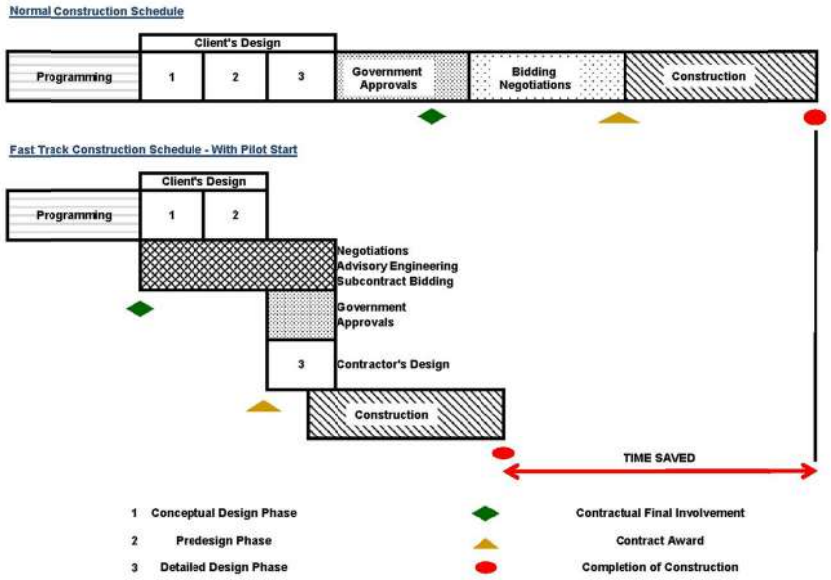

Figure 1 Normal vs. Fast Track Project Development

2 AN INSIDE LOOK AT FAST – TRACK DESIGN AND CONSTRUCTION PROCESS

Although an exact definition is still evolving, fast track construction is usually defined as the overlapping of functions and development stages to reduce the amount of time needed to complete a facility (Devine et. al., 2007). Most construction projects follow a predetermined sequence: concept, schematic design, design development, construction documents, and construction administration. Fast-track construction overlaps these stages to allow construction to begin earlier and proceed at a faster pace. The normal process of construction scheduling involves the performance of a series of discrete functions, one after the other, in a predetermined sequential order. The customary logical order of these functions is programming, design, governmental approvals, bidding and negotiation, contract award, construction, and finally, completion. Each activity is virtually completed before the next commences. A fast track design and construction project can be defined as a project where the time constraints of an Owner to utilize a structure cause standard design and construction procedures and timelines to be compressed in order to meet the Owner's schedule for use of the structure. In a project of this type, time is of essence, thus the need for time sensitive decisions is critical and takes precedence over other forces that would generally have greater weight in a standard design and construction sequence. In a fast track project, processes that normally would run in sequence must be run in parallel. Therefore it is imperative that the process is fully mapped out prior to commencement. It is also vital that full cooperation and well defined lines of communication between Owner, Designers, Consultants and Contractor are established early in the process.

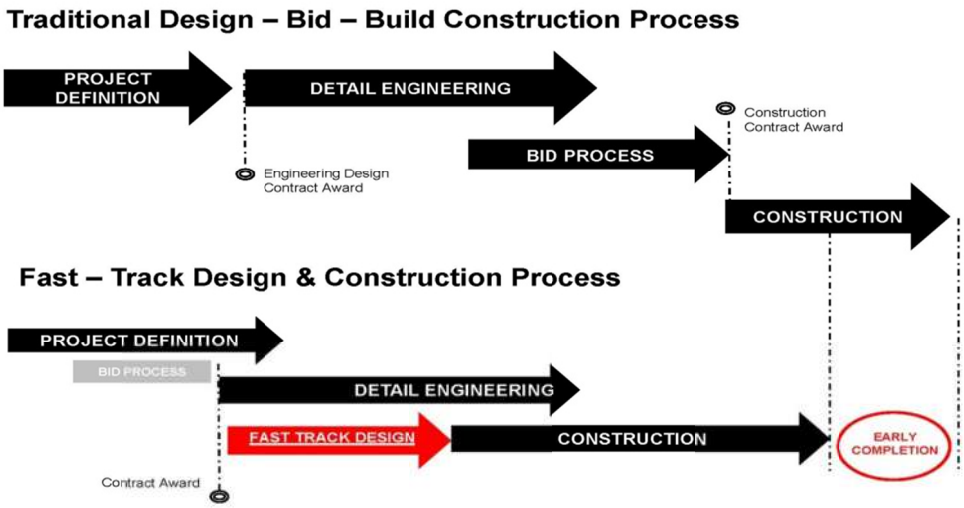

Figure 2 Design – Bid – Build vs. Fast Track & Construction Process

Fast track typically involves the process in which construction commences prior to the completion of all design and final (coordinated) construction documents. It is a system that overlaps the three traditionally separate, distinct phases of a construction project: design; bid/contract award; and build. It usually involves the phased completion of the design drawings and a stage-by-stage bid or construction kick-off process that awards individual work packages as they are completed. While the Contractor begins construction on the first phases, the Designer completes the remainder of the contract specifications. Under this project development system, construction work begins before the project design and construction documents are complete, which allows work to start sooner than using the typical method. Fast-track design and construction process has been around for decades and now, according to some industry associations, accounts for as much as 40 percent of major building projects. (Fig. 2)

Design firms that have the ability to deliver projects with speed and efficiency have a decided competitive advantage. The growth of fast tracking procedures are testaments to the value Clients place on speedy delivery of their projects. “Time is money,” is today’s Client’s adage, and a shortened schedule can be a deciding factor in selecting the best design firm for the job. (Fig. 3)

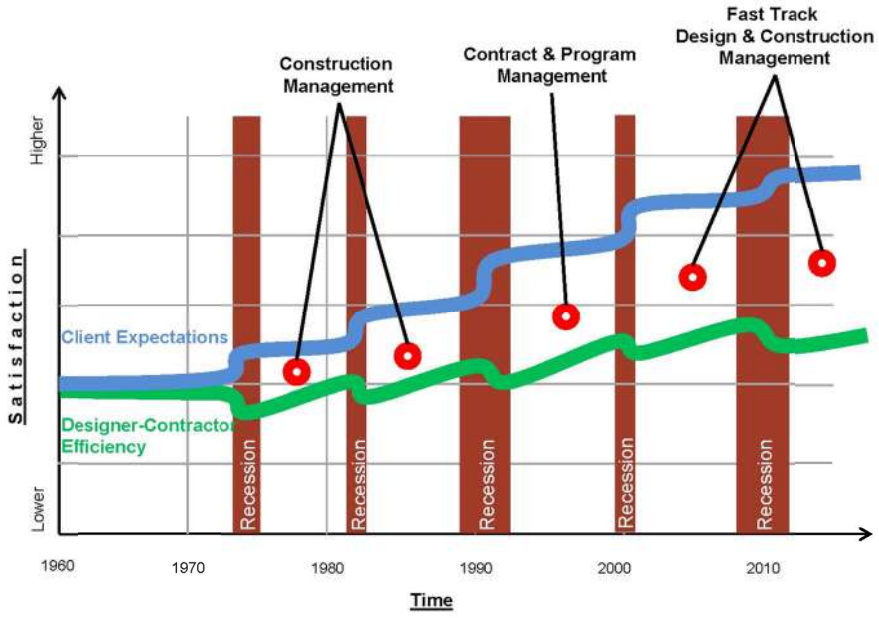

Figure 3 Bridging the gap between Client Expectations and Designer/Contractor Efficiency

3 THE UPS AND DOWNS OF FAST-TRACK CONSTRUCTION

Fast-tracking offers many potential benefits, such as an earlier project completion date, a reduction in the amount of time spent before the work starts compared to the traditional bidding process, and cost control by awarding the work in stages. The collaboration between the Owner, Contractor and Designer in schedule development provides the earliest possible completion of the work. As a result, the project may also be financed over a shorter period of time. In fast-tracking, materials can be ordered early in the process rather than after the entire design process is finished.

However the potential disadvantages of fast-track construction include the risk of dealing with incomplete information, the prospect of beginning a project without knowing the final cost, and increased difficulty in making cost-effective design changes.

Fast-track benefits will be obtained only through comprehensive planning throughout the work, the creation and maintenance of a detailed critical path schedule, and adherence to strict budgetary guidelines. Although risk is inherent, the reward can be great. The key to success is for everyone involved to study and understand the risks and embrace the uncertainty. Most importantly, they must deal with the potential risks through careful negotiation of the contracts, both between the Owner and Designer and/or the Owner and Contractor(s). (Fig. 4)

With fast-track construction, the time traditionally consumed before construction by the bidding process is spread out over the course of the work. The Designer can assist in controlling costs by providing suggestions for value engineering. The advantage of a fast track project is the ability to meet shortened deadlines, which are becoming typical in today's business environment. The disadvantage of a fast track project is that with the emphasis on time, budgetary considerations cannot always be fully analysed due to time constraints and so some decisions must be made without being able to quantify the budgetary impacts of those decisions. Also, because the fast track process requires that decisions, once made, cannot be second guessed or reworked without significantly impacting the schedule, which of course is the main "thrust" of a fast track project, the ability to redesign, is limited if the fast track deadline is to be accomplished. Lastly, it is not uncommon for a fast track project to commence without the final budget being fixed.

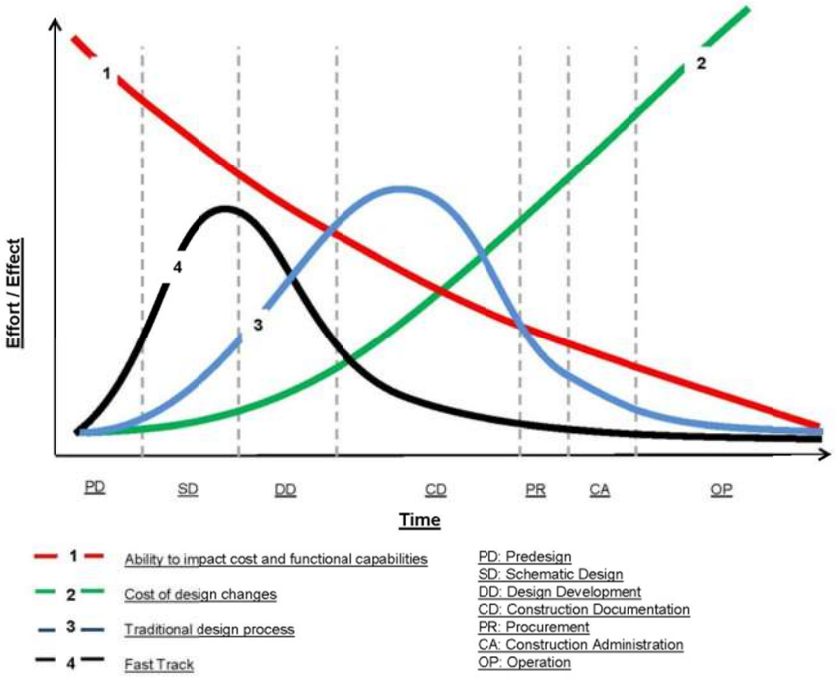

Figure 4 Effect on project cost due to different design approaches

One issue with a fast tract project that cannot be controlled is that of governmental regulations, review, and approvals. While the team members will communicate early and as needed with those governmental entities that will ultimately have to approve the project, the ability for the Contractor's and Designer's team to compress the review and approval process is extremely limited. Thus the schedule could be negatively impacted if approvals are not forthcoming as anticipated within the schedule.

On the downside, fast-tracking limits the Owner's ability to make substantial design changes once construction has begun. Starting construction on a given phase before design documents are complete could lead to a significant number of change orders. Even worse, such a tactic may ultimately require certain work to be redesigned or replaced. To gain the advantages and minimize the disadvantages of fast-tracking, retailers, Contractors and Designers must have a thorough understanding of the process and its risks. They must also agree to work as a team.

4 DESIGN RISKS, PROFESSIONAL LIABILITY INSURANCE, CONTRACTUAL ISSUES

Despite a strong initial interest, the market for project professional liability insurance of fast track design and construction tunnel projects has all but dried up, and the few insurers who still offer this coverage do so under strict guidelines. The reasons behind the insurance industry's reluctance to participate in this market are complex, but the bottom line for fast tracking participants is that their insurance coverage may not match up to their liabilities under the contract. When it comes to risk of errors/omissions claims and professional liability exposure of design professionals, the proponents of the fast track method point to the reduction of the liability exposure due to the enhanced collaboration and interaction of Contractors and Designers in the design and construction process. The opponents of the method state that professional liability exposure for design professionals (e.g. omissions and errors due to design incompleteness or lack of coordination) is substantially greater on projects utilizing the fast-track approach due to extremely high time stress. When it comes to designing and constructing a project, however, speed can also kill. When meeting a tight schedule is the Client's overriding concern, quality and detail are likely to suffer. For Designers and Consultants, that almost certainly means added risk, added cost, lower profits and the potential for expensive litigation. For these reasons, the term "fast track" should send up warning flags for all competent design firms.

There are substantial risks to the Designers involved in fast-track tunnel projects, i.e.:

a) The time cushion between design and construction is lost, eliminating opportunities to identify and correct design errors or omissions before construction begins.
b) Extra time is spent spinning off separate construction documents for each of the bid or construction packages.
c) It's difficult to maintain consistency in design and detailing when work is performed rapidly or out of sequence – or by multiple primes.
d) Multi-tasking is needed to administer the bidding and construction administration phases while simultaneously completing the design and construction documents. In smaller firms, this practically means Designers have to repeatedly suspend design efforts in order to focus on the bidding and early construction.
e) Fast-track projects are apt to have modifications and expensive change orders the Client does not always understand nor anticipate.
f) With project changes, more time is spent on construction administration activities.
g) Late design changes mean some of the construction work itself will need to be modified or even demolished.
h) Perhaps the biggest challenge Designers' face, however, is the inexperienced or unrealistic Client who considers the expected time and cost savings of fast track as guaranteed. Unless the Client is experienced and educated, he will attribute additional

costs from modifications and change orders to Designer's errors, omissions and incompetence, rather than being inherent risks in the fast-track project development method.

The only sure way to avoid fast-track problems is to avoid fast-track projects altogether. But in today's rapid-paced construction environment, that may be nearly impossible. There, are, however, several steps to take to lower the risks associated with fast track, as follows:

1. The first prevention tool is education to bring the Client's or Contractor's expectations in line with reality. It must be ensured that the Client understands and acknowledges the risks and potential liabilities he must bear by choosing fast track.
2. Modifications to design documents are inherent in the fast-track process and should be appropriately budgeted.
3. Reasonably added costs associated with fast tracking must be anticipated in the project budget and an ample contingency fund has to be established to include both design and construction changes probably necessary because of possible omissions, ambiguities or inconsistencies in the plans, drawings and specifications.
4. Acknowledgement that the final construction cost of the project may exceed the estimated construction cost. Agreement by the Client or the Contractor to set aside a reasonable reserve as a contingency to be used, as required, to pay for any such increased costs and changes.
5. The design contract should also address the added liability risks and costs associated with the fast track method. The agreement should describe the potential risks of the fast-track process to both the Designer and Client and allocate these risks equitably. A sufficient scope of services to provide for any additional services necessary on a fast-track project is necessary.
6. Acknowledgement that employing the fast-track process requires from the Designer to provide design services that overlap with construction and are out of sequence with the traditional project-delivery method.
7. Establishment of the Client's responsibility when authorizing changes from plans and specifications. In an attempt to stay on a fast-track schedule, the Client may directly authorize changes in the construction documents without Designer's approval or knowledge. Acknowledgement that if the Client or anyone for whom the Client is legally liable makes or permits to be made any changes to reports, plans or other construction documents without obtaining the Designer's prior written consent, the Client shall assume full responsibility for the results of such changes.

No matter how strongly the abovementioned clauses and agreements are worded, all involved parties should go to extraordinary lengths to document every step of their discrete involvement in a fast-track project. Detailed notes must always be kept on what changes were made, who made them, why they were made, what the ramifications were on previously designed or constructed work and why some tasks were done out of sequence.

5 DESIGN MANAGEMENT AND COMMUNICATION FOR FAST TRACK PROJECTS

The design manager's goal is to complete a project on schedule and within budget while meeting standards of quality in order to meet the Client's needs. A consulting engineer has been defined as a "professional experienced in the application of scientific principles to engineering problems". In addition to rendering a professional service, the consulting engineer also operates a business. Regardless of the form of the engineer's organization, the final product a Client receives must retain the same professional characteristics and meet the same professional standards. Consulting engineers usually have several Clients, and they must select methods of operation to suit their own and their Clients' needs best. During a fast track project an engineer will be required to phase the design into packages before the

entire project is completed. The Designer will have to make accurate assumptions regarding the completion of the design to avoid changes to earlier design packages under this system.

In addition, there is great pressure on the Designer to provide an extremely economical design to allow the Contractor to complete the project within the construction bid price. The Designer is required to provide support services during the construction phase to assure that the project is being built in accordance with the design documents. Periodic inspection and consultation during construction are normally part of the Designer's obligation under fast track design contracts. These tasks include periodic visits to the site; issuance of clarifying drawings, if required; and checks of construction method statements and Contractor's shop drawings for compliance with design documents. Full-time on-site representation, contracted separately as an addition to the design services, is a must.

When determining the design firm most qualified to undertake a project, an Owner or a Contractor should consider technical qualifications, ability to absorb the additional workload in relation to the firm's capability and existing workload, experience, reputation, financial standing, and past accomplishments in related fields. In the development of a project, it is important for a Client to receive complete and competent professional advice. The fee paid for proper professional services will be a wise investment. Value engineering may also be incorporated as part of the fast track design process. The team makes recommendations, as appropriate, for revisions that will improve the design, increase value or affect cost savings. The earlier value engineering occurs, the more effective it is in reducing costs. Once a project is undertaken, the work involved has to be completed regardless of time or cost. Still, the design manager must operate within a budget so design can be performed efficiently. A Designer does not deal with a tangible product for which the firm can establish a cost per unit and operate on a production line basis. Nor should the firm go to the extreme of establishing a control in such a manner that the cost becomes more important than the product (Muller, 2004).

Based on several case analyses of fast track design processes (Den Otter et al., 2001) it became obvious that conventional design processes function poorly within fast-track projects. Improvement of design methods, techniques and instruments is needed to facilitate these high-pressure design processes as well as high professional skills of the design team members to collaborate and communicate effectively. Solutions might be found in integral design methods with an increased level of collaboration and communication facilitated by electronic media for design information flows.

The aim of fast track design is to shorten the throughput time of the design process. To analyse as well as to improve fast-track design projects two systems of control aspects must be considered in their mutual dependency. One system consists of the three coherent elements: time, money and quality, the other system consists of the coherent elements: people, process, and object. (Fig. 5)

A design process is defined as a sequential process in which progress is measured in terms of used time and remaining time left, because the time to deliver is restricted by the Client. On the other hand, the design process is highly cyclic and iterative by nature through which a team of Designers develops satisfying solutions to the Client's demands. Within this field of tension, the effectiveness of communication and understanding between the participants in a design team highly determines the progress of the design team process (Paashuis, 1997). Communication follows collaboration. Effective communication enables collaboration between participants in a team. People often have difficulties co-operating and communicating inter functionally on their own initiative, because it forces them to go beyond their existing roles, responsibilities and authorities. Reymen (2001) states that "People who do not do so, will likely not be triggered by a method to do so". Design communication is of essential importance to facilitate the progress of the fast track design. Within the triangle of people, process and object, information handling is positioned in the middle because it is dependent of all three elements. In this view the design process is the organized processing of interdisciplinary design information between design partners. Within fast-track design, it is necessary to work as parallel as possible. In this environment, interaction between the team members creates a collective frame of references as well as a collective judgment for the

design problems and their related solutions. Integral design can be defined within this context as simultaneously designing parts of the overall design, keeping appearance to the status of the overall design. The distribution of design information between the design partners is of essential importance for the progress of the design. Therefore, fast and easy to use information and document management systems might be the ideal solution. (Fig. 6)

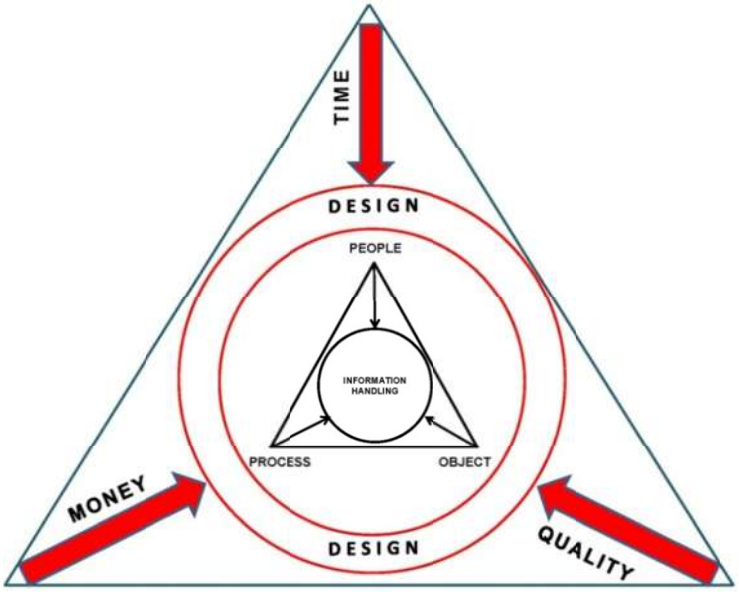

Figure 5 Principal parameters affecting the Design Approach

Working parallel to each other is important to keep track on the progress of the design team members and the status of the produced work. For that reason working together in the same room as a design team and not coming out before a satisfying solution is reached seems to work very effectively and efficiently. Team dynamics, team spirit, and getting the "chemical reaction" in the team are keywords for this working method. In terms of information richness the highest rate is scored by face to face meetings. Media richness is defined as the degree/amount in which a communication tool offers the possibilities, within a certain time interval, to effect the desired change of understanding of people (Daft et al., 1986). Changes in design often need meetings. The highest richness is for face to face meetings; the lowest for rules and procedures, written text and numeric documents.

Information behaviour has to deal with the skills, habits and background of design participants (Davenport, 1997). It concerns information sharing, information overload and how to handle multiple meanings. Design team members are regarded as knowledge and information workers. Often personal and organizational knowledge to a certain extend is shielded from others in the project environment, while this is actually their personal value added to the design. This inhibits true collaboration. So the level of information sharing is rather corrupted by psychological factors bound to the characteristics of professional behaviour. Within design teams, a collective, coherent and consistent project knowledge base is of essential importance to improve the performance of design teams.

Trust within the team that participates in the fast track design and construction project is necessary to neutralize "Big brother effects". Dependent on the understanding and trust to each other in the team, team members will be able to communicate with less misinterpretation (Jarvenpaa, 1999). Handy (1995) defined seven rules for teams to co-operate: 1)Trust is not blind, 2)Trust needs boundaries, 3) Trust demands learning and openness to charge, 4)Trust is tough, 5) Trust needs bonding, 6) Trust needs touch, 7)Trust requires leaders.

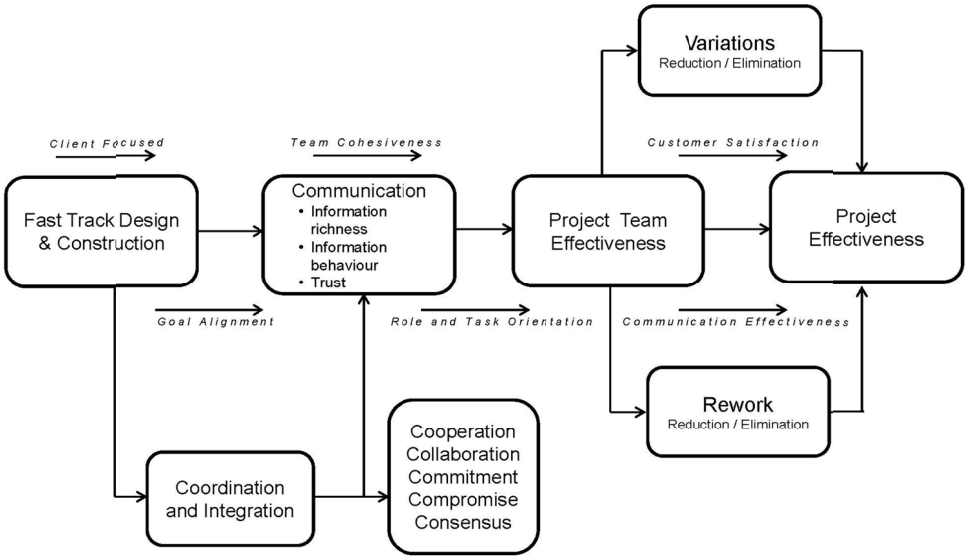

Figure 6 Fast Track Approach towards Project Effectiveness

6 FAST TRACK DESIGN AND CONSTRUCTION RULES

The key to a successful fast track process is a commitment by the entire team to the duties and schedules, as well as flexibility and good communication between all parties. A way to think about a fast track process is to imagine a large pool of water with a release valve at the top of a hill. If you take your time to construct a clear straight channel for the water to flow down, once you release the water, it will flow fast and straight unimpeded to the bottom of the hill. As soon as that stream is impeded, the water gets diverted and the path to the bottom of the hill is slower and more convoluted. The project is the pool of water and our plan is the channel. With this in mind, the following guidelines on bilateral responsibilities and governing rules and prerequisites are given below:

- ✓ clear chain of command for Contractor and Designer communication and interaction,
- ✓ very few decision making individuals clearly designated by both parties,
- ✓ no changes when decisions have been made,
- ✓ well thought out program of requirements,
- ✓ very close contact with the Designer during construction through establishment of Designer on site follow up services,
- ✓ very strict control and quality assurance of any subcontractors activities,
- ✓ constant interaction and communication with the Checker/Client to be systematically informed about the running construction activities,
- ✓ immediate verification of the highway alignment and topographical surveying by the Contractor for providing the Tunnel designer with accurate data,
- ✓ effort to avoid design processing delays for insignificant modifications or corrections on drawings,
- ✓ urgent establishment of a well thought out requirements' program,
- ✓ ability to make immediate design decisions,
- ✓ engagement of all authorized personnel and vendors early with their commitment to meet established deadlines,
- ✓ schedule regular design meetings according to phase of construction,
- ✓ enforcement in terms of schedule – if deadlines are missed in this process, this will factor into current and future progress, and will impede onsite activities.

- ✓ management of design activities onsite relative to scopes of work under Contractor's purview,
- ✓ systematic follow up of design fees developed during phased construction.
- ✓ clear definition of communication chain with designated people in position to facilitate timely decisions.

The usual way of shortening the time scale is by increasing productivity. Another way of saving total elapsed time would be by compression of the time schedule. That is, by overlapping some of the functions, doing two things at the same time. This would be accomplished by starting a new phase of work where possible before the preceding phase is completed. Organizing the project to produce early completion by the technique of concurrent or overlapping time scheduling is the essence of fast track construction. The usual procedure for overlapping functions entails the Designer's earlier involvement in the project. However, there is no generally accepted standard system or approach. Every fast track project can be different.

Under normal time scheduling, prudent Designers make great efforts to check their work product in the hope of culling out errors and to ensure that the work of all disciplines is coordinated. Even with the most rigorous reviewing and checking procedures, some errors and anomalies will inevitably slip through. Although Designers should have checked their work meticulously at this point, some errors and omissions will undoubtedly be later uncovered during the completion of the documents and in the field as construction progresses. Also, as the drawings and specifications are being further developed, situations will arise where it would seem advisable to change previously released designs and details. To correct errors or to change to more advantageous designs will require more change orders than would be common under normal construction scheduling. This will be an inconvenience to the Contractor, sometimes an embarrassment to the Designer and usually added cost to the Owner. There is also the added risk of jobsite confusion and construction delay. Although the Fast Track Construction method has the potential of saving time, there can be no reasonable expectation of always saving money. The saving is primarily in the value of the time saved, if it occurs.

Fast Track Construction should not be attempted unless the Client is under real pressure to achieve a specific mandatory completion date. The Owner, Designer, and Contractor must all be completely acquainted with the process and must enter into it fully aware of the inherent problems. They must be willing to engage in the give and take of compromise, and to assume reasonable and flexible attitudes. To accomplish this, there must be solid decision-making processes in place, open communication and an overall commitment to keep on task. For a fast-track schedule to work, project managers should put together an internal multifunctional team to make decisions in a timely matter. The pressure will be on everyone involved to meet the desired completion date. To ensure everyone is aware of decisions and any changes, there must be open communication between all parties involved. Especially with a fast-track project, all parties involved should follow-up with documentation.

7 CONTRACTOR - DESIGNER TEAMWORK, THE KEY ELEMENT OF SUCCESS IN FAST TRACK

The FTD approach was successfully applied in the following major tunnelling projects:

1. The Maliakos Kleidi Motorway in Greece, a Concession Project, being constructed by MALIAKOS KLEIDI CJV (HOCHTIEF – AKTOR – J&P AVAX – VINCI CGP – AEGEK – ATHENA) from 2008 to 2011, which involves the design and construction of three (3) twin bore highway tunnels. Tunnel T1 (of approx. length 2*2km), Tunnel T2 (of approx. length 2*6km, with 2 smoke extraction shafts of approx. length 170m and a smoke extraction gallery of approx. length 100m) and Tunnel T3 (of approx. length 2*2,8km. All tunnels

were excavated with NATM, drilling & blasting techniques and/or heavy mechanical means by top heading and bench and their final lining was of reinforced and/or unreinforced concrete C30/37. The encountered geology consisted mainly of amphibolites, marbles, phyllites, amphibolitic schists, limestones, serpentinized peridotites, ophiolites, cataclasites-mylonites, alluvial deposits and with max. overburden ranging from 150m to 300m. The tunnels designs were executed with fast track procedures by the consortium of OK CONSULTING SA, ILF CONSULTING ENGINEERS & HOCHTIEF CONSULT INFRASTRUCTURE.

2. The Elefsina – Korinthos – Patra – Pyrgos – Tsakona Motorway in Greece, a Concession Project, being constructed by APION KLEOS CJV (VINCI CGP-HOCHTIEF - J&P-AVAX – AKTOR – GEK/TERNA - ATHENA) from 2008 to 2011, which involves the design and construction of Twin Bore T26 Panagopoula Tunnel (of approx. length 4km and 3km respectively, with a ventilation adit of approx. length 500m and emergency accesses of approx. length 150m) and Twin bore Platanos Tunnel (of approx. length 2*1,6km). Both tunnels were excavated with NATM, drilling & blasting techniques and/or heavy mechanical means and their final lining was of reinforced and/or unreinforced concrete C30/37. The encountered geology consisted mainly of conglomerates, limestones, cherts and marls and with max. overburden ranging from 100m to 270m. The tunnel designs were executed by OK CONSULTING SA with fast track procedures.
3. The KRABBE Tunnel Construction project was procured by the Ministry of Public Works of Albania under FIDIC Conditions of Contract and was awarded to AKTOR SA during 2011. The project involves the design and construction of a Twin Bore Highway tunnel at the Tirana – Elbasan motorway section in Albania, of approx. length 2*2,5km. The tunnel is excavated with NATM by using drilling & blasting techniques and/or heavy mechanical means and the encountered geology consists mainly of molassic formations of sandstone and siltstone alterations, thick-bedded sandstones, siltstones, rare interlayers of conglomerates and with overburden up to 210m. The tunnel designs were executed by OK CONSULTING SA with fast track procedures.
4. The PATHE MOTORWAY which is the main North-South motorway of Greece included the design and construction of the tunnel sequence at Kakia Skala section in the south entrance of Athens, consisting of twin bore AS1 and AS2 Highway Tunnels (of approx. length 1,2km and 2km respectively) and AS3 Single Bore Highway Tunnel (of approx. length 1km). The project was constructed between 2000 and 2004 by AKTOR SA All tunnels were excavated with NATM by using drilling & blasting techniques and/or mechanical means and the final lining was of reinforced concrete C20/25. The tunnel complex is located at a seismically active area and the encountered geology consists mainly of limestones, with a max. overburden up to 200m. The tunnel designs were executed by OK CONSULTING SA with fast track procedures.

The foundation of the success to accelerate and launch the construction activities in all abovementioned major highway tunnel projects was the effective teamwork developed in all cases during the tender period between the Contractor and the Designer. The Tunnel design and construction team was effective in developing teamwork during the project tender process and members of the design team attended pretender meetings dealing with proposed construction methods and evaluation of potential tunnel design and construction options. At these meetings, innovative ideas and solutions were encouraged from all individuals, without regard to individual expertise or seniority, and regardless of whether an idea seemed promising on first inspection. Through this process, many apparently implausible suggestions were explored. A number of these, although unworkable in their original form, either appeared in the final solution in a new guise, or acted as catalysts to spark off new lines of enquiry.

To summarize, the essence in human resources management of the fast track design approach in all aforementioned tunnels, was:

- ❖ To encourage everybody to contribute ideas, regardless of whether their expertise was in permanent works design, temporary works design or construction methods;
- ❖ To encourage imagination and creativity;
- ❖ To accept ideas with an open mind, even if they made little sense on first inspection, and to explore whether they could be improved by exposure to other ideas from different sources;
- ❖ To compare ideas as they developed in open discussion, using as far as possible objective criteria for comparison.

During the tender periods of all those projects, the Designer and Contractor shared the common goal of minimizing construction cost. The Contractor was able to provide reliable and current cost data to the Designers, assisting them to better realizing the cost implications of their design decisions. The Designers made effective use of this information because they fully realized that a price would be attached to their design before submittal to the Owner, and that the joint proposal for the project could be rejected because the price was too high.

The fast track tunnel designs not only minimized quantities, but also focused on ease of construction and customization to this particular Contractor's preferred methods of working. The choice of construction methods was perceived by all as an input to the overall tunnel design process, rather as something to be determined after design was complete. Many of the construction methods adopted were not intrinsically, easy or cheap in them, but were chosen because they fundamentally improved the tunnel design, bringing indirect, but very significant cost and schedule benefits. (Fig. 7)

Bringing the Contractor and Designer together allowed both parties to develop a better understanding of the risks inherent in the project and to adopt designs and construction methods which helped to minimize risk.

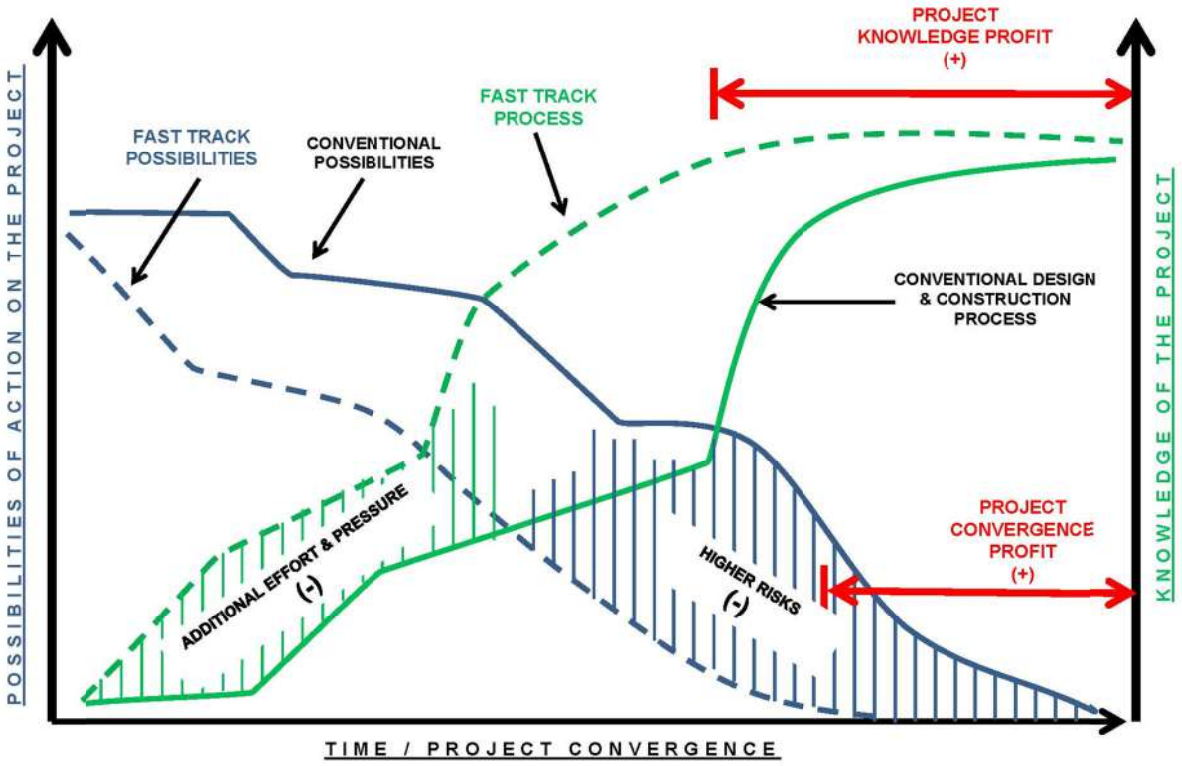

Figure 7 Project Knowledge and Convergence Profits by using Fast Track Design Approach

For tunnel projects of this scale a full independent check including independent analysis and verification or a scholastic review by the Independent or Supervising Project Engineer is always essential for ensuring safety. However, participation of the reviewing member in a traditional role would inevitably lead to delay in a fast track project. In almost all

cases it was necessary for the reviewing member to work “within the Contractor’s organisation or spirit” and to be able to work in parallel with the design team rather than waiting until completion of the design before commencing work. This allows an interactive checking process whereby analytical results can be compared prior to production of all detailed drawings. The reviewing member is also able in this way to take a proactive role providing technical advice and help developing solutions to design problems which inevitably arise during the design process. However, by breaking down some of the barriers of independence between Designer and Checker there is the risk of collaborative errors leading to failure of the checking process. This risk is mitigated by the consultant's experience of independent checking and understanding that the risk is present.

The main constraints, the managerial actions and sequential steps of the fast track tunnel design procedures followed in all these projects are given below (OK CONSULTING SA, 2004):

1. Design drawings for the portal cuts were given to the Contractor (in incomplete forms, not for submission to the Checker) for starting the excavations in the tunnel portal cuts areas. No technical reports and analysis with calculations were submitted.
2. The geotechnical interpretation for the portal cuts was not completed. The design drawings served only the purpose of starting an urgent construction process.
3. All the drawings constituted the common design platform performed at an emergency level, which would then have in any case to satisfy the final designs of the portal cuts, which would be submitted at a later stage to the Checker according to the existing tunnel design contract.
4. The tunnel design contract was running independently and there were some cases, where some additional excavations and slope protection measures should be executed thus adapting the fast track design drawings with the final design drawings.
5. The Fast Track Design referred to the sequential and progressive execution of detailed construction drawings for excavation and initial support of the tunnels, including all the required specifications, construction steps, materials, sequence etc., in order to enable the fastest possible start of the underground construction works. Such a process does not comply with the contractual provisions and the formal prerequisites of the projects, but it is obviously a useful and efficient tool to accelerate the construction process provided that an agreement in principle between the Contractor, the Checker and the Client is achieved.
6. The Fast Track Design did not include the elaboration of any structural or geotechnical calculations – analysis and technical reports for official submission to the Checker and/or the Client. It could only include some brief technical descriptive reports accompanied by empirical or semi empirical calculations which justify and substantiate the packages of the relevant construction drawings. It only served as a flexible tool to enable construction works being performed for a certain (and certainly restricted) time period until they would be fully covered by the necessary official design submissions to be performed under the existing contractual schedule and the responsibility of the Contractor.
7. The Fast Track Designs were based on the evaluation of all the geotechnical information and data available until their starting date, as well as on technical estimations and simplified calculations for achieving a safe design in due time.
8. Any responsibility with regard to the communication, response and approval process with the Checker and/or the Client was kept by the Contractor, provided that the Designer would efficiently participate and contribute in any unofficial meetings necessary.
9. Usually, the Checker and/or the Client, after a “fast – eye” check of the Fast Track Drawings expressed his “agreement in principle” or “no objection” for the works to proceed and expected to receiving the official designs for performing the contractually foreseen review or independent check.
10. The Fast Track Designs constituted an absolutely internal technical process strictly determined between the Designer and the Contractor and it was totally independent of

any existing contractual process to be followed by the completion of the contractually foreseen official designs.

11. The Fast Track Designs were performed by following an official instruction of the Contractor to the Designer and the responsibility for the application of the highway alignment and the fulfilment of any contractual and official prerequisites referring to the necessary design submissions (highway alignment approval, tunnel risk analysis study approval, preliminary civil works and E/M tunnel design approval, geotechnical interpretation report approval etc.) was kept by the Contractor.
12. The Contractor was aware that probable modifications or changes on existing construction stretches already constructed through the Fast Track Design approach due to the finally adopted design according to the contractual design submissions were probably expected during the execution of the Final Design (more detailed geotechnical evaluation, structural and analytical calculations, comments and requirements of the Checker and/ or the Client etc.). The Designer would of course make any possible effort to minimize the extent and importance of such modifications (if any).
13. The supply of design services from the Designer to the Contractor in the frame of the Fast Track Design approach was covered by an independent services contract agreement between the Designer and the Contractor, while the official design submission flow, already foreseen by the construction contract was always separately maintained and satisfied up to the last end for the issue of the final certification of the project.

8 CONCLUSIONS

The construction industry is a fertile field for development of new terms, usually either for promoting certain ideas or for confusing the “messages” to gain economic advantage. A stylish new term of the past twenty-five years is Fast Track Design and Construction. It is a term that rolls easily off the tongue and conjures up images of expedition, economy and efficiency. The word “track” connotes a direct, unswerving route to a predetermined destination (O’Leary, 2006). The term as a whole promises efficacious and accelerated design and construction process and we can all accept that time is money. But, is it reasonable to expect that fast track construction will always live up to these optimistic prospects? The answer is a qualified yes. It could work well and in most cases it does. But only under specific conditions. And only when the Owner, Designer and Contractor all conduct themselves properly and reasonably. Otherwise, the results can be extremely disappointing and distressful to all concerned.

Time is money. With fast-track construction, this is particularly true. On most fast-track projects, tunnel construction sites may have already broken ground before the detailed designs and drawings are complete. It can be a risky venture, but one well worth the risk in terms of time saved.

The decision to participate in a fast-track project should start with careful selections. Each party should proceed only if a competent and sophisticated Designer, a quality project, a strong contract, an adequate fee, experienced Contractors and good working personal relationships are all around. Then a commitment to open communications and frequent exchanges of information is of vital importance. Teamwork with clearly aligned and defined goals and objectives is crucial to a successful fast track project based on an early start and finish concept and within budget, instead of embarking for a trip to uncertainty.

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