MAJOR RAILWAY WORKS IN HONG KONG - ON TIME & WITHIN BUDGET TO OPERATING SUCCESS

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ABSTRACT: Kowloon Canton Railway Corporation (KCRC), a wholly Government owned entity, standing alone, is required by law to produce a return on investment based upon prudent commercial principles. In this paper KCRC's successful on time and within budget approach to constructing US$9.4 billion of new railway works over a time span of eight years, is described in the context of risk allocation between the Employer and Contractors compatible with International practice. Contract awards were made after competitive tendering fully in accordance with the World Trade Organization rules applicable to procurement by Government agencies.

1. INTRODUCTION

In November 1994, the Governor of Hong Kong decided to proceed with the Western Corridor Railway, and in the following January, KCRC were invited to submit proposals to build and operate the railway. This had been preceded by findings of the Government's Railway Development Strategy from the late 1980's onwards.

The original brief was for three rail services to be provided, namely a domestic service for Northwest New Territories residents, a cross-border rail service from the Guangdong Province of southern China to the Kwai Chung Container Port in Hong Kong, and a cross-border passenger line. The alignment of the railway is much the same as that we see today.

In 1993, 40 million cross-border passenger trips were recorded, a number that was forecast to double in 10 years. During 2003, there were in fact about 120 million passenger trips across the boundary between the Hong Kong SAR, and Guangdong/Shenzhen.

KCRC was a natural choice to build and operate this new railway, having been in existence since the year 1910 when it opened for traffic with two steam locomotives for mainline operation and a further two for shunting purposes. In September 1963, the last steam locomotive was scrapped, being replaced with diesel-electric locomotives from 1955 onwards. Diesel became the backbone of the KCRC passenger and freight services between Lo Wu at the boundary and the Hung Hom terminus in Kowloon, until the electrification programme was completed in stages during 1982-1983.

The KCRC electric trains were configured in 12-car consists, each train receiving power from the overhead 25-kV, 50 Hz single phase supply operating up to a maximum speed of 120 km/hr. During the early days of operating the electric railway, occasional service interruptions occurred when the overhead catenary system was disrupted by arcing at transformer locations. This was subsequently designed out of the system by relying principally upon ground-earth return to the main traction power supply transformers. An advantage of the 25kV system was compatibility with the system adopted by China, since it was expected that trains would again resume services between Hung Hom and Guangdong, the original Kowloon-Canton railway.

In fact through train services did recommence from early 1980's onwards. In addition to the domestic service along East Rail, KCRC receive freight trains from China into Hung Hom drawn by diesel locomotives.

From 1988 onwards, KCRC began operating a Light Rail service in the north and western parts of the New Territories linking the new town areas between Tuen Mun and Yuen Long.

2. RAILWAY DEVELOPMENT

KCRC had been seeking to enhance its rail freight capability from 1991 onwards, with a port passenger line proposal to the Government in 1993 and building on this for the Western Corridor Railway detailed feasibility study culminating in its full proposals to the Government during 1995. By April 1996, a total of US$55 million had been spent on proposals leading to West Rail, involving banking, legal and land specialists, apart from its core consultants. Given the status of the project, however, the West Rail Division comprised mainly project consultant contract staff.

During this period of planning, the primary factors behind the viability of the railway were revenues from passengers and freight, involving passenger trip models, fare assumptions, and the attractiveness of a rail freight service in and out of southern China. Despite the integrated nature of the approach taken, it was clear from the forecasts that the commercial viability of the railway would be satisfactory only with the inclusion of freight services. To provide a better base for viability calculation, it was also assumed that property development would take place along the railway with income flowing to the Corporation.

Passenger forecasts were based on the same assumptions adopted by the Government for its own railway development studies, assuming a 1992 travel pattern and a conservative population forecast of 7.5 million in mid-2000. Of particular importance, the population in the north and west parts of the New Territories would increase by about one-third which would represent the major part of Hong Kong's population growth.

Cross-border passenger trips were expected to grow at an annual rate of about 5 per cent, considered a conservative projection.

In November 1996, the Governor-in-Council responded to the proposals from KCRC by deciding that a new railway known as West Rail would be built in phases with the First Phase extending from Tuen Mun, through the new towns of the west and north parts of the New Territories, linking with the urban area by way of a long section in tunnel with an initial terminal station in West Kowloon. RDS I also identified the need to enhance the capacity of East Rail for passenger services, and to provide a second crossing for rail passengers into Shenzhen, the Special Economic Zone which neighbours the territory.

The Government conducted a second Railway Development Study which was made public in 1998 alongside various studies related to road development in the territory and additional crossings into southern China.

Government's stated aim was to bring railway travel within easy reach of Hong Kong's entire population, using both KCRC services, and those of the Mass Transit Railway Corporation which runs broadly from east to west, either side of the harbour and the new airport with the urban area and central business districts.

KCRC's envisaged programme of capital projects was expected to lead to a ridership of 2.2 million by 2008, about double the combined East Rail and Light Rail ridership at the commencement of West Rail. This would mean KCRC route length increasing by 140 per cent, and an increase in average Net Fixed Assets of 40 per cent. The book value of assets was forecast to increase by a factor of about 5 times over the period, with a substantial part of this funded by borrowings, resulting in the net book position.

3. THE CHALLENGES

Given that Hong Kong is one of the most-densely populated cities in the world, major difficulties were foreseen in acquiring the necessary land for the project involving almost 1,000 lots in private ownership, necessitating the enactment of a new railway Ordinance under which land could be acquired expeditiously, subject to a period of about one year for gazettal, objections and statutory approval for compulsory purchase. Of particular concern was the impact on the community at large arising from the construction and operating noise of the railway, given that the railway alignment would cross a relatively rural part of the territory between the growing new townships, with much of the area crisscrossed by drainage channels and subject to the risk of flooding during heavy rainfalls. Rainfalls can exceed 300 mm per hour in localized areas. It was decided therefore that the railway would run entirely above ground to minimize land and community impacts in the north and western parts of the New Territories, running above major drainage channels and at locations where no other option was available due to ground-level constraints.

Viaducts also avoided disrupting existing road transportation corridors, and maximized the opportunity for connectivity between rail and road users at the above ground stations. As we shall see later, the adoption of railway viaducts and appropriate technology also made it possible for West Rail to be designed in compliance with the very strict Noise Control Ordinance which was already in place, and the Environmental Impact Ordinance which was enacted in April 1998. These Ordinances are amongst the strictest in the world in terms of protecting the community from noise and intrusive impacts, particularly so for the New Territory section of West Rail, much of which, runs through areas identified as rural by nature and therefore much more sensitive to railway noise intrusion.

Property development, having been identified as an important factor underlining operational viability, envisaged a construction of perhaps 44,000 homes over a seven-year period in proximity to or above West Railway followed by similar property development along other new railway lines. Apart from property sales providing revenue to fund the capital expenditure on the railway, residents in these new homes were expected to be an important source of patronage for the new railway. The number of new homes would also be a significant contribution to Government's long-term housing strategy that was in force at that time.

Interconnectivity between KCRC and the existing or envisaged transportation links can be categorized under three headings. Firstly the stations provide direct passenger interchanges between existing railways, and all stations are provided with means of easy access for passengers arriving or departing by taxis, buses and cars. Under the second heading, provision was made for West Rail to accept freight services from China via a future Northern Link from Lo Wu connecting with West Rail just before entering the underground section. The third heading covers the southern section with direct connections into MTRC

stations, and separately ground level facilities for passengers using taxis, buses and cars at East Rail Extension links.

4. TECHNICAL STUDIES

During 1997, the alignment and design of the railway was progressed by a further series of technical studies up to the stage of about 25 per cent scheme design completion. This enabled a project to be fixed in terms of a capital expenditure budget, the acquisition of land, funding cost and pre-revenue operation expenditure prior to passenger services. This was fixed at US$ 8.3 billion in Money of the Day (MOD) terms, taking into account a forecast inflationary trend over the likely seven years to project completion.

The operation and planning parameters adopted for the detailed design studies were based upon the existing East Rail and 12-car train consists for convergence with an ultimate KCRC network for passenger and freight services. The successful design and procurement of a safety critical system for train control and signaling, was recognized as a dominant critical factor from the start of project implementation. The process adopted for the procurement of the train control system for West Rail was a “funnel” procurement approach. KCRC invited expressions of interest from suppliers based on system concepts, and potential suppliers then responded to the Corporation’s system concepts by way of a formalized documentation process backed up by computer simulations. A fixed sum was paid to those who were not invited to proceed and three suppliers were eventually invited to tender for the train control and signaling contracts against very clearly specified system requirements. The funnel process decision and the activities involved occupied much of the first year, but enabled certainty to be injected into the operating characteristics of the railway at the stage when the resulting benefits would be of maximum value to the heavy civil engineering design which followed.

By the end of this first year, the technical study programme had been substantially completed, and five engineering consultants were appointed to proceed with the detailed design of West Rail leading to the preparation of the tender documents. Each consultant was awarded a contract in competition with at least four other consultants on a pre-qualified list of consultants, submitting lump-sum proposals for design services on the one part against a clear brief of services to be provided. By this time, the Government had become concerned that the increase in cross-boundary travel would eventually create problems for the existing East Rail, and requested KCRC to commence technical studies which would lead to the East Rail Extensions being undertaken in parallel with West Rail.

5. KCRC TAKE CONTROL

Given the scale and complexity of the project, it was essential that strong and effective leadership was exercised at all times by the KCRC Management Board represented by the CEO and a Capital Projects Group led by the Senior Director with strong input from the operating divisions of KCRC, and direct control by the West Rail Division. A specialist land consultant was engaged to provide expert staff for all aspects of the land delivery programme, except those matters which had to be dealt with by the Lands Department of the Government as statutory procedures.

The Environmental Impact Assessment (EIA) which was a deliverable from the technical study phase was a foundation document for the designers to develop the technical solutions and construction methods satisfying the construction phase and operational noise constraints. A further deliverable from the technical study phase was the West Rail General Conditions of Contracts and the draft specifications for capital works and railway systems. Reference was made to similar documentation used in Hong Kong projects by the Government, the Mass Transit Railway Corporation and the Airport Authority. All of these documents embrace the doctrine of fair allocation of risk between the Employer and the Contractors, which is enshrined in the FIDIC Conditions of Contract. The adoption of FIDIC principles enables KCRC to attract a broad base of highly experienced International contractors, as well as local contractors, when inviting tenders for construction of the new railways.

Let me just remind you of the FIDIC principles. The conditions were published for the first time in 1957 and are recognized by international agencies such as WTO and the World Bank for procurement of major construction works. The conditions are intended to fairly allocate risk and responsibilities between the parties involved, including independent administration of the contract through the construction phase. As we can see from this slide, the relationship between the client and the contractors in terms of risk allocation, varies widely. KCRC chose to adopt a lump sum approach with fixed price tender subject to measure variations if so instructed.

The background to this was the obvious need to avoid the causes of project under-performance such as these which are set down on this slide. A strong KCRC team would at all times be proactive in dealing with the relationship between the Engineer supervising construction and the Contractors. In this respect, the KCRC Conditions of Contract clearly describe the KCRC Project Team’s involvement, differing somewhat from the FIDIC relationship between Employer and Contractors which was considered unnecessarily passive. The adoption by KCRC of the team approach for West Rail and the East Rail

Extensions was a major factor in the successful accomplishment of new railway construction.

A multi-contract approach was adopted to ensure that the Corporation had maximum visibility over the performance of contractors and the work in progress. KCRC's strong client-based organization was able to ensure real time co-ordination and leadership from the highest level. Given that KCRC had not previously built stations of the complexity needed for West Rail, a fully designed approach was adopted. Consultant designers provided working drawings for civil works, building services, architectural building services and finishing works. The contractors were obliged to provide for the integration of works by the system specialist contractors within the station public and back-of-house areas.

6. CONTRACT AWARDS

KCRC approach to the award of contract was one of a proactive partnership backed up by a fair and equitable process, both the tendering process and assessment was as transparent as possible. The Corporation's Managing Board was the authority for approving all contract awards. Contract documents clearly describe how the construction risks would be dealt with by KCRC and its contractors. In the event of a dispute arising during the construction of works, the documents also described how these would be dealt with whilst construction was in progress, including the variation process by which the contractors would be fairly paid for works found to be outside the tender documents.

Contractors having been pre-qualified were required to submit a tender in full conformity with the drawings and specifications attached to the tender documents, failure to do so resulting in automatic rejection of the tender. Having done so, however, contractors were allowed to tender alternative proposals fully priced in the manner required for conforming tenders, but taking advantage of a contractor special expertise.

For civil construction, the majority of contracts were awarded by way of fixed lump sum against detailed drawings for construction prepared by the design consultants. Since the design risk was with KCRC, the Corporation also accepted unforeseen risks that might emerge, for example, unexpected ground conditions. Special civil works such as tunneling and railway system works including signaling and track works, were awarded by way of Design and Build Contracts. For these better contracts, since the design was undertaken by the contractors or specialist designers employed by the contractors, the design remained with the contractors, and any unexpected ground conditions or similar unforeseen risks were for the contractors to find design solutions.

Contracts had provisions for variations, and to facilitate this all contractors tendering were required to submit a schedule of rates and major quantities, which was subsequently incorporated into the relevant contract.

7. CONSTRUCTION HIGHLIGHTS

The size and complexity of designing and constructing the West Rail above ground stations, was a daunting challenge to everyone involved. Tuen Mun Station is an example illustrating the sheer size and impact of building the station in an established new town area, above an existing drainage channel, the width of which can be seen in the distance. This resulted in many programme and construction constraints especially to minimize the risk of flooding. The adjacent homes and schools also had to be protected at source from noise impacts resulting in strict control and limitations upon working outside the normal day time hours. The ground level areas for the future passenger bus terminal can be seen together with access ramp to concourse level, taxi and car drop-off areas. Light Rail which crosses the station at its far end and runs in close proximity to one side, was raised above existing level and connected into the station at concourse level, both for passenger convenience and to improve road junction flow characteristics. The viaduct approach to the station, as at other discreet locations along the railway, is enclosed to contain noise impact.

Tin Shui Wai Station is another example, this time illustrating the problem of building above an existing road junction and Light Rail, with a school in close proximity. In common with other stations, the platform area is enclosed by platform screen doors, which open and close together with the train doors, enabling trains to stand alongside the platform in an open air environment, and thereby reducing the with of the station box.

Kam Sheung Road Station was built on a green field site following land resumption in Kam Tin Valley for the West Rail Depot. The station is surrounded by a large transport interchange and a vehicle carpark area for passengers from surrounding areas using ground transport.

During the Environmental Impact Study for West Rail, the problem relating to railway noise, both during construction and operation, became a serious issue. Within enclosed stations, operating noise could be contained. However, the problem of operating a railway within a completely contained viaduct, some 30.5 km in length, was clearly unacceptable from the KCRC point of view and brought with it safety related issues, particularly should emergency situations arise.

The original viaduct design was developed with noise control measures in view. An important part of this

approach was the design of the rolling stock itself, which incorporated skirts along the whole length of each carriage to form a noise plenum under the train, with areas of the underside at bogie locations covered with sound absorbent material and special noise reduction measures provided for the air-conditioning units mounted at roof level. The pass-by level for the train was specified not to exceed 83 dB(A) on ballasted tracks at 130 kph. In the event the multi-plenum noise containment system for the viaduct section proved satisfactory, except at a few locations where the line of sight to sensitive receivers resulted in slight excedence of the Noise Control Ordinance limits for very early morning operation. At the receivers, these noise limits range from 60-65 dB(A), and were finally achieved by introducing plenum enhancement measures at rail track level coupled with additional noise barrier protection along the top of the viaduct parapets.
In designing the viaducts, the approach taken was to maximize constructability, including parallel work on foundations and superstructure to minimize overall programme duration for viaduct decks to be available for the following contractors. At the same time, the Corporation realized that contractors would propose alternative designs and these were accepted at the time of tender, subject to tenderers demonstrating that the alternative provided equivalent noise and vibration reduction performance. In the event an alternative design for the viaduct was accepted.

Apart from the design characteristics of the viaduct to absorb train generated noise and vibration, special track work system along the whole railway was employed. This involved considerable research into floating slab systems then under construction or in operation, particularly by the railway authority Toronto, Canada. Sections of floating slabs had previously been employed in Hong Kong by MTRC, but the West Rail system was by far the longest and most ambitious length of such track undertaken anywhere at that time. Apart from design consideration, the construction of the floating slab tracks along 90 per cent of the 30.5 km railway was seen as a potential programme risk, but in the event the contractors involved developed an effective method of construction which enabled the permanent way to be completed and commissioned in good time for the following railway system contractors.

The innovative solutions for environmental performance and noise control adopted for West Rail were also adopted and enhanced for East Rail Extensions.

8. TUNNEL DESIGN

From Kam Sheung Road Station and after passing through the Maintenance Centre, the railway is entirely in tunnel for the remaining 9 kilometres to the present terminus station at Nam Cheong. The first length was driven by conventional rock tunnel methods, and at 5.5 km. it is the longest transportation tunnel in Hong Kong. The contractors' alternative design, which was accepted, adopted a single tunnel approach with a center-wall to provide the necessary separation between the tracks, four hours of fire protection, and passenger evacuation.

The section of tunnel after Tsuen Wan West again was a contractor alternative design, using over part of its length "Earth-pressure-balanced tunnel boring technology". At 8.4-metre external diameter, this was the largest tunnel boring machine ever employed in Hong Kong, and successfully overcame a potential major programme delay which arose in resuming a large multi-occupant industrial building that straddled the route of the tunnel. Apart from this the ability to tunnel at shallow depth in the decomposed soil and rock conditions, without serious disturbance at ground level, avoided cut-and-cover construction that otherwise would have impacted on the existing major roads and footpaths above the tunnel alignment.

9. STATION DESIGN

Mei Foo Station is located within a public park, and in part below an existing major road viaduct structure with the soffit of the viaduct serving as the roof of the rail tunnel at this location. The alignment places the railway about 20 metres from Mei Foo Estate, a large residential complex. The resulting community problems required intensive communications relations by the project team, supported by the KCRC corporate relations team.

Mei Foo and Nam Cheong stations are major interchange stations between West Rail and the Mass Transit Railway, with interchanging passengers also to use fully air-conditioned routes with escalators at change of levels. Barrier free access is provided throughout the new railway for those who are visually-impaired, or unable to walk. Lifts are provided from platform to concourse levels and where necessary to public transport interchange facilities. At Nam Cheong Station, KCRC and MTRC came together to design the station as the first combined station in Hong Kong, serving both rail networks, with the station being controlled jointly from a single control room. Passengers using Octopus contactless travel cards move between the two rail networks, through a single set of automatic gates.

Architectural building finishing work for the station interior in general adopts the MTRC experience with concourse and platform floors finished with resin-bond terrazzo tiles, and vertical wall surfaces are covered with vitreous enamel panels. Ceiling systems generally comprise absorbent panels which drop down for ease of maintenance with space for light fittings, public address speakers and the like. All level changes are provided with escalators with adequate capacity

for peak hour travel and emergency evacuation. Station signage also received particular attention given the size and the number of destination points surrounding the West Rail stations in particular. The security system throughout the railway is directly accessible by the dedicated police unit from the Hong Kong Police Force, which patrols the railway networks.

10. TESTING AND COMMISSIONING

The testing and commissioning of all railway systems and the rolling stock was designed into the systems from commencement, and proceeded as intended up to and including pre-revenue trial operation. The outbreak of SARS during the early part of 2003 presented a number of challenges to be overcome, since this period had been programmed for completion of the field testing and commissioning phase, particularly integrating systems installed by different contractors. The commissioning of the bus interchange facilities requiring the introduction or re-routing of bus services, re-scheduling Light Rail services and staged opening the new Light Rail platforms for passenger use. The traveling public at large was informed by way of various Government departments and KCRC of the arrangements to be in place for the opening of West Rail by way of a fully co-ordinated media campaign.

During the trial running and pre-revenue phase which preceded the opening of West Rail in December 2003, initial difficulties resulting from EMI and ground current effects primarily on the signaling and train-borne control systems had to be overcome. This required a concentrated team effort over a period of six weeks, involving contractors and KCRC staff. Punctuality and delivery targets for operating the railway were set at 95% and 97% consistently, before the decision was taken to open for public services. Since the opening of the railway, these percentages have climbed to over 99.5%, a remarkable achievement for a new railway of this nature. Two new lines of East Rail Extensions were opened in 2004, and the lessons learnt from West Rail have been applied to very good effect in both the construction and operation of these new railways.

11. ON TIME AND WITHIN BUDGET

West Rail was successfully opened ahead of the date set by the Government at the commencement of the project, and the original capital cost budget of US$8.3 billion was reduced to US$6 billion. A substantial reduction in cost was achieved in 1998 by means of a value engineering exercise at the detailed design stage. When it became obvious that cost estimates were forecast to increase to an unacceptable level, a major value engineering exercise led to the reduction of train lengths from 12 cars to 9 cars maximum. This alone resulted in shorter stations, and substantial cost savings.

In summary, the approach to West Rail can be considered a success, particularly since it was the first major project to be undertaken by KCRC for very many years, and indeed was the largest civil engineering project in Hong Kong since the new airport. The Quarterly Review Meetings (QRM's) introduced by KCRC are recognized as a major contributory factor, a partnering approach which is the most effective means of undertaking major projects. The QRM's were conducted both formally in opening sessions as well as in closed-door workshops. The involvement of KCRC's construction and operation staff in problem solving with designers and contractors has been beneficial for both West Rail and East Rail Extensions.

East Rail Extensions are likewise ahead of programme with two out of three extension lines already serving the pubic. The forecast cost to completion for all current railway works is still within the US$9.4 billion original budget.

A particular aspect of the QRM sessions for the new railway projects was the emphasis given to site safety, including when necessary a dressing-down of the senior management personnel in attendance on safety matters. Together with regular safety audits of all sites, these activities contributed to the impressive overall safety records achieved by West Rail, with only one fatal accident throughout the entire project. The original incident rate of 1.6 reportable accidents per 100,000 hours work at the end of the project had been brought down to about 1 per 100,000. The construction industry in Hong Kong at large has had a bad safety track record over very many years, and the efforts being made to improve the situation have been significantly assisted by the West Rail performance. This has been taken forward and further improved on by the East Rail Extensions team.

12. FINAL REMARKS

Project management is undoubtedly an art, not a science, and relies heavily on people dynamics. The major railway projects successfully completed by KCRC during the past eight years, have again hammered home this point. But problems will be encountered, and part of the art is to find the best win-win solution by negotiation and compromise if necessary. This was the case with West Rail, when dealing with unexpected ground conditions. It was necessary to enter into supplemental agreements with sub-contractors. These agreements resulted in programme delays being recovered, such that completion was finally achieved in accordance with the programme dates set in 1997 at the commencement of the project. Time against cost, and value for money was the over-riding objective when negotiating supplemental agreements, in the light of unforeseen events encountered during construction.

Wrapping up major problems has enabled the final account process for the new railway works to move forward speedily, and with a few exceptions contractors have accepted final valuations of work done and payments have been made accordingly.

Thank you for the opportunity of being with you today. I hope that this highlight of some of the lessons learnt by KCRC, in successfully completing major railway projects, will be helpful during your future careers.