Lantau approach span launched into final position; probably the largest and stiffest incrementally launched

KSM the contractor’s view

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SIMPLY establishing the site proved to be a major logistical exercise, as there were no existing facilities whatsoever. Marine docks were built on both Islands, and on Lantau, which has very little level ground, a significant amount of earthworks and a sea wall had to be completed. On both islands dedicated concrete batching plants were established.

There was no road access to the site, so high-speed catamarans were employed to Transport staff and labour from Hong Kong, Kowloon and several other points to the site. There was no water on site; it al had to be imported for all usage including for concrete production. All materials had to be brought in by sea mostly by barge.

Electric power on Lantau was provided from a 1500kva feeder from China Light and Power, while on Ma Wan all power was self-generated with diesel generators, giving a supply of 1750kva.

Building the Kap Shui Mun presented the international consortium of contractors with a number of challenges

Sidespans

Although neither the longest nor the heaviest total weight of deck to be incrementally launched, the sidespans are possibly the largest and stiffest cross-section erected by this method, resulting in sliding bearing reactions in excess of 2500 tonnes.

Both sidespans were launched as two separate boxes with the central railway envelope trackbed and top slab struts constructed after launching. Each box girder was divided into 10 segments, each typically 18m long.

Differing formwork and launching techniques were employed by each of the two joint venture partners responsible, the only common aspect being the braced reinforced concrete column temporary piers.

For the Ma Wan side span a custom designed formwork system was employed, supported on a 20m high reinforced concrete falsework from which eight of the ten segments were launched. Launching utilised a hydraulic 'lift and push machine', a prototype Japanese designed system. Two segments were cast insitu, one on the supporting structure to the casting bed and one on ground supported falsework.

For the Lantau side more basic forms were used, with all ten segments being pulled out of the casting bed using strand and pulling jacks. A two stage casting bed was developed, with the lower carriageways and webs being constructed within a second stage bed.

Given the structural discontinu-

Ma Wan tower and approach spans, connecting to the Ma Wan viaduct (extreme left)

ity between the Lantau approach span and the side spans of the Kap Shui Mun, the final launch of the Lantau side spans was over 90 metres long, taking 3 days to complete. Pulling gear had to be relocated to the tower in order to complete this operation.

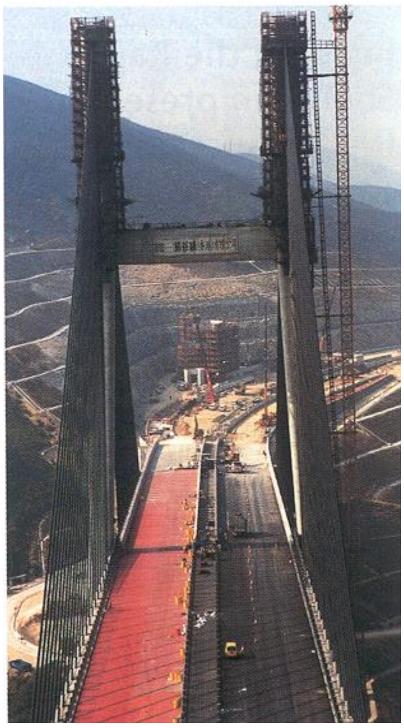
Tower and Piers

The Lantau tower is founded at 0m on competent rock, while the Ma Wan tower is founded at 12.0m. A self climbing fully enclosed formwork system was selected for the tower construction. A cycle time of typically five days for a 400m lift was achieved for the simpler lifts, with anything up to 12 or 14 days for some of the more complex lifts incorporating changes of section and post-tensioning for the two struts. The inclusion of the three stay cable anchorage boxes within the launching nose required a notch to be cast into the towers to allow the side spans to be launched through them.

Lower struts were constructed on falsework supported on the plinths between the tower legs at foundation level. Upper struts were constructed on proprietary trusses lifted into position with strand jacks. Piers were constructed using conventional crane handled formwork in typically 40m lifts.

Main Span

It was decided at an early stage that the steel fabrication of the 39 main span deck units would be carried out in China at Shekou. The chief concern was that the tight tolerances and quality control could be achieved by the Chinese fabricators. As a result, Chinese supervisor were sent for training in Japan, and Japanese and European supervisors worked in China during the fabrication - supervising the shop drawings, setting out, welding and painting. As a result very little adjustment was required when the units were assembled on site. A purpose built paintshop was constructed, and the painting was carried out by a separate sub-contractor from Singapore.



Finishing works in January 1997, looking towards Lantau

At the same time the assembly area was being prepared adjacent to the bridge. Due to late design changes a barge dock was built between two assembly lines locate either side to accelerate the construction cycle. This allowed the loading operation to be independent of tide and weather and provided shelter during storms. In addition mobile weather shelters were provided over the assembly bays to allow work to continue in the heat and rain of the humid Hong Kong summer and saved valuable construction time. The maximum component weight was 35t, which required a 135t crawler crane to assemble the units, and tower cranes were used for the concreting operations.

The sliding of the 500t units onto a 2000t barge went very smoothly. The barge was floated in and then ballasted to sit on the floor of the dock, and the units were winched on using two sets of strand jacks of 200t capacity. A full channel closure was required for each tow-out and required close supervision with the Marine Department, to control the very busy shipping lanes. The barge was towed out, anchored in position, and the units lifted by purpose-built segment erection cranes fixed to the previously erected segment. Despite the strong and varied currents in the channel only one anchor was lost during the lifts - and that was due to a 40m deep mystery hole found in the middle of the channel. Hydraulic rams pulled the segment horizontally for mating and bolting up, with final adjustments made before concreting a one metre stitch in the upper and lower carriageways and installing the cables. The fabrication of the closure segment was left as late as possible and then the final cut was carried out on site to achieve the best fit.

Cables

The cables were supplied by Bridon UK and installed by DSI (Far East).

About to close the span, in March 1996, just ahead of Tsing Ma

The total weight was 2330t, with each cable consisting of between 51 and 102 parallel mono strands. The corrosion protection of the strands includes a hot dipped galvanised coating with an average of 300g/m^2. There was concern that this thickness may clog up the wedge grips at the anchorage during stressing, but this did not materialise. A factory system was set up on the deck for cutting, preparing and installation, with the anchorages pre-assembled wherever possible in the assembly yard. The strands were initially stressed individually with mono jacks to one tonne, then the entire cable stressed with a calibrated multi-strand jack with a maximum capacity of 1500 tonnes. The final cable force was determined by the designer on site, and required very few changes from the theoretical calculations.

HDPE sheathing was then assembled on the deck and slid onto the cable in 3m lengths. This was then welded and winched over spacers fixed to the cable which had been fitted using purpose-built gondolas. Finally the anchorages were grouted with an epoxy resin and sand compound, which needed careful control in the high temperatures.

The critical path for the erection of the units was always with the cables. The erection cycle for each side started at 20 days but rapidly reduced to 14 days, with one remarkable cycle of 11 days helped by the summer of 1995 which had fewer than normal typhoons. As a result the final unit was lifted into position on 18 March 1996, just ahead of the Tsing Ma bridge.

Third time lucky for Ma Wan

A MASSIVE structure that is overlooked even more often that the Kap Shui Mun is the 503m-long Ma Wan viaduct, which connects the two bridges. This is a twin-decked six span post-tensioned concrete structure at a height of some 40m above Ma Wan Island. It is supported on some of the largest circular pot bearings ever made and on heavily reinforced concrete piers, pile caps and 2.5m diameter hand excavated piles (locally known as hand-dug caissons) socketed into rock. The maximum span is 87m.

At time of tender it was intended to construction the viaduct by casting each span (N & S separately) on the ground and then jacking into position onto huge hammerheads cast on the piers. Variable ground conditions and the extensive amount of temporary internal stiffening which would have been necessary led to the first re-think, after award of the contract.

The revised plan was to cast the superstructure in-situ on a travelling falsework/formwork system. The traveller and partially constructed superstructure would have been supported on intermediate steel props until each span was completed and stressed. After each segment had been cast the traveller was to be released and moved forward to the next section. This would have been one of the largest structures ever to have been constructed using this method – but it was not to be.

Proposed development of Ma Wan Island meant that the requirements were amended to allow for future provision of slip roads. This meant that instead of the box being of relatively consistent profile, it would now be progressively widened over almost half its length. The traveller, for which the temporary works had already been designed and approved, would no longer be suitable.

Massive falsework system was among the largest ever erected

The third and solution was to use a heavy duty falsework system which was designed, supplied and erected by RMD (Hong Kong) Ltd. This comprised of 100t capacity proprietary megashore props seated on temporary driven piles. RMD also provided a proprietary formwork system for the actual box construction. Each span of the viaduct was cast in 21.75m long segments in three pours: base slab, web walls, and top slab.

The end span, where the viaduct meets the Tsing Ma, had servere access restrictions due to the concurrent construction of an electricity substation. It was therefore necessary to fabricate in-situ a massive steel structure to span the substation, which was also capable of withstanding the large construction loadings.