When 155yr old major city sewer collapsed

emergency team restored flow in 3 weeks - repair in 16 weeks

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Knostrop WwTW lies to the south of the city of Leeds and caters for around 700,000 people. Flows from the sewerage network in this area are discharged into the works WwTW via two large diameter sewers. During the heavy rain storms of August 2004, the larger of these sewers collapsed causing extensive flooding in parts of Leeds. The site of this collapse was in a recycling yard belonging to a ready mix concrete supplier. The sewer was constructed 155 years ago as a 2.4m diameter brick sewer with a flattened ashlar masonry invert with depth to invert of around 10m.

Knostrop Sewer: Placing of concrete pipes - note man standing upright inside pipe *photo:courtesy MWH*

Emergency works

Peter Duffy Ltd are strategic partners within the *Gleeson MWH* joint venture employed by Yorkshire Water in their Western area to carry out design and construction of all wastewater schemes during the AMP3 period. This joint venture is occasionally called upon to respond quickly in the event of emergencies such as this.

Following an initial call out and attendance by Peter Duffy Ltd, it was quickly realised that a major situation was unfolding and to deal with this incident an emergency incident team was formed. A sequence of operations was evaluated and decisions taken to resolve the immediate flooding problems with pumps being established at strategic locations to transfer flows to the other inlet sewer. This huge task required great teamwork and an immense round the clock effort from all parties.

Temporary pumping station

Having solved the immediate problem a more robust temporary pumping station was required to prevent further flooding from occurring during the repairs. A 12m long 6m wide and 12m deep cofferdam constructed using sheet piles formed the sump to house eight 12 inch submersible pumps positioned below the invert of the existing sewer. This pumping station could handle the majority of flows (up to 5,000 litres per second) thereby draining the sewer to allow safe inspection. A system of temporary steel rising mains conveyed the flow 130 metres to Knostrop works for treatment.

Investigation & repair

Once the pumping station was operational attention turned to determining the cause of the collapse and to provide a permanent solution. Initially, three main options were identified, these were:

* to replace the damaged sections using a pre-cast concrete pipe in open cut trench;

* to utilise the existing structure by the insertion of a GRP jacking pipe within the sewer:

* an offline tunnel constructed by a pipejacking method.

All options were based on the assumption that repair was required along a 120m length between manholes. All solutions were costed and reviewed by the team, and after careful consideration it was agreed that the best option was to use the GRP jacking pipe as a sleeve within the existing sewer. This choice was based upon it being the most cost effective, the quickest to install and causing least disruption to the ready mixed concrete suppliers recycling operations. In addition, this option had the least potential to cause damage to an existing high pressure gas main which crosses the site.

The design of the sewer over this section was based on the existing sewer, the infill grout and the GRP pipe acting as one structure. The

size of the GRP pipe was determined by a combination of surveying the existing sewer to ensure the proposed pipe would fit (the existing sewer was no longer truly circular with vertical and horizontal deflection of over 300mm being observed) and by design.This involved calculating both the thickness of the pipe required and the effect that the reduced diameter would have on the hydraulic performance of the sewerage system as a whole. Initial investigation works which covered approximately half of the length of affected sewer gave the team confidence that a 1.94metre outside diameter, 70mm thick, GRP pipe would pass through the sewer without causing further damage.

During the design period a further cofferdam was constructed around the suspected area of collapse. Excavation down to the sewer within the cofferdam showed the upstream section to be severely distorted and unable to accept a sleeve of sufficient size placed within it. The steel sheet piling was, therefore, extended, the damaged sewer removed and replaced with 2.4m diameter concrete pipes. These pipes were laid in a special high strength reinforced concrete cradle to achieve an appropriate bedding factor.

Both permanent and temporary works designs and methods of construction were quickly developed and implemented. During this phase of the work close collaboration within the team ensured that the design solution was both practicable and cost effective.

Programme
An ambitious programme was developed for the renovation of 120m of sewer with a target for both the GRP pipe jacking and open cut works to finish simultaneously enabling a junction chamber to be constructed and the flows to be turned back into the sewer as quickly as possible to prevent the risk of flooding and to reduce costs by dismantling the pumping station and pipework.

Shield and first pipe prior to jacking within the sewer *courtesy: MWH*

The total solution utilised both no-dig and open-cut techniques providing a direct comparison to be made between the two techniques.

Outcome
Emergency pumping arrangements were installed immediately and the temporary pumping station and pipelines were in operation within three weeks of the incident occurring. Flows were returned through the sewer by the end of November 2004, allowing removal of the temporary arrangements.

The whole extensive project was stabilised, designed and constructed within a 16 week period.

No further flooding occurred during construction and the asset life of the affected section of sewer is restored. Further investigations on the upstream section revealed the sewer to be in a similar poor condition and at severe risk of collapse. A second scheme to renovate a further 400m of sewer using the no-dig technique is thus currently under construction.

Design work for this scheme was carried out by MWH with Peter Duffy Ltd being the contractor.

Conclusion
Excellent team work between all parties was essential during the initial phases to rapidly alleviate flooding and liaise with third parties. Both permanent and temporary works designs and methods of construction were quickly developed and implemented. Close collaboration within the team was key to ensuring that the design solution was both practicable and cost effective.

This incident demonstrated what true partnership is about, selflessly working to solve a large scale problem very quickly.■

Note: *The author, Dave Young is Project Manager, MWH*