Bridge Crossing Design in Shunde

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ABSTRACT

In Shunde, rivers and waterways separate different zones and towns. It is not a convenience for pipeline Gas Company to build their pipeline network. River crossing pipe lying becomes unavoidable. Traditional Horizontal Directional Drilling (HDD) is well developed and become a very famous solution for river crossing. However, there are still some underground obstacles which cannot solve by HDD, for example, huge rocks and gravel layer. For this case, Bridge Crossing Technique becomes provide an alternative for river crossing.

This paper focuses on Bridge Crossing Design and gives suggestions in related subjects.
Introduction

The focused project is called Wu Sha Bridge Crossing Project. As the gas pipeline network of Shunde Gas Company is not connected to Wu Sha (area on the east of Shunde), Shunde Gas Company have to pay about 289,000RMB/month more to buy gas from Pan Yu Gas Company. This project aims at laying the pipeline to Wu Sha in order to supply gas to the Wu Sha customers and cut off the expenses on buying gas.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Sales in Wu Sha</td>
<td>320,000 m³/mth</td>
</tr>
<tr>
<td>Gas Cost from HP Company</td>
<td>3.3 RMB/m³</td>
</tr>
<tr>
<td>Gas Cost from Pan Yu Gas</td>
<td>4.2 RMB/m³</td>
</tr>
<tr>
<td>Difference between two</td>
<td>320,000 x (4.2-3.3)</td>
</tr>
<tr>
<td></td>
<td>= 289000 RMB/mth</td>
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This project chose bridge crossing as the solution because the typical HDD is not able to perform due to geotechnical challenge. By attaching a pipeline on the newly constructed Wu Sha Bridge, gas supply to Wu Sha is achievable.

However, a great challenge in design is raised as, unlike HDD, there is no a specified GB standard tells how to perform a design work on bridge crossing. It is because there is a conflict between two industries.

While the City Gas Design Guideline (GB 50028-2002) allows bridge crossing pipeline works, the Bridge Design Guideline (CJJ11-1993) did not. Therefore, no further investigation is placed to set up a standard for bridge crossing. Fortunately, there is an update on Bridge design guideline in 2011, which allows placing a gas pipe on a bridge which is less the 4 bar with safety measures. Therefore, bridge crossing technic will become a more favorable in China for river crossing pipe laying project. Therefore, it is very valuable to set up a design guideline in order to standardize and to ensure the quality of future bridge crossing project. Wu Sha Bridge Crossing Project becomes the first reference to set up this guideline.
Design Criteria

As a bridge crossing project will expose the gas pipe. It has to face the problem being caused by the environment. Therefore there are so many areas that need to be considered while doing the design works, e.g. nearby vibrations, thermal changes, waterway clearance, utilities clearance, ultra-violent damage, rain, humidity, access platform, etc.

This paper covered five of them which are very important and well covered in the recent state the drafted guideline.

1) Traffic Vibration

As the traffic load of Wu Sha Bridge is very high, the pipe will vibrate. A large vibration will damage our pipe. The limit, in terms of ppv, is 13 mm/s for above ground steel pipe. If the vibration overs this limit, vibration absorbing measures have to be added to protect the pipe.

Investigation can be done by a well calibrated electric sensor called virborgraph. It is used to record the vibrations on a particular point for a period of time. A well rounded investigation should collect the records on at least three locations at the peak traffic load period.

The maximum result of Wu Sha Bridge is 4 mm/s which is less than the limit more than three times.
2) Thermal deformation

As the temperature varies in a day, exposed steel pipe will face thermal deformation according to the changes in the surrounding temperature. The problem raised by thermal deformation can be very large. Fig x shows the basic structure of how a pipe is fixed on the bridge. The red triangles are the supports.

![Diagram showing how pipe is fixed on a bridge]

Fig 2 How pipe is fixed on a bridge.

When Temperature increases, steel pipe will expand and a large force will be induced. If the force is large enough, either the supports will be broken or the pipe being curved due to buckling, like pressing a ruler. Even the force is very small, a cyclic force will induced inside the pipe. Similar to break a metal spoon by bending it so many times, the steel pipe will break due to fatigue.

Expansion Loop and Expansion Joint are the typical solution for thermal deformation. And the expansion loop is more favorable due to its higher reliability and lower cost compared to expansion joint. However, expansion loop occupies much more space than expansion joint. So for limited installation space allowed by the bridge owner, expansion joint is chosen for the Wu Sha Project.

![Diagram showing expansion loop size]

Where, 
\[ L_A = \frac{3}{2} \frac{D \Delta L}{\varepsilon_{allow}} \]
\[ L_B = \frac{L_A}{2} \]

- \( L \) = Length
- \( D \) = Pipe Diameter
- \( \varepsilon \) = allowable bending strain
3) Expansion Joint

The function of EJ is similar to a spring. It will be contracted or elongated in order to absorb the deformation inside the pipe. And there are three types of deformation, which are Axial, Lateral and Angular. Some EJ can only cater for one type of deformation. For the EJ can cater for all types of deformation, we called it universal EJ.

![Fig 3 Types of deformations](image)

According to the deformation being created, respective EJ is used.

However, according to The Standards of Expansion Joint Manufacturers Association (EJMA), the design of using a single axial EJ in a straight pipe line is the most preferable suggestion. Curved and complicated pipeline should be separated into different straight sections unless there is any obvious benefit for other design.
4) **Emergency measures**

As safety is the top priority in Towngas, measures to protect the pipe from accidents are important. There are different levels to protect an exposed pipe. Firstly, Physical Protection is the most effective protection. As river crossing subjects to risk on clash including ships or vehicles, hiding the pipeline in a concrete trough can safely protect the pipe. Even this might not be a favorable solution due to rejection from the bridge owners, clash barrier should be set up to protect the pipe from direct clash.

Secondly, no matter how strong the clash barrier is, there might be a chance that a huge vehicles or ships can break the clash barrier and then damage the pipe. So it is important to remove the danger immediately once damage is made. Automatic isolation valves can quickly stop the gas leakage, once there is a great pressure drop detected. Two valves is needed as gas will return from downstream even the upstream is blocked.
Fig 6 Automatic isolation valve stop the gas leakage

It should be reminded that the gas supply to the downstream customer have to be maintained. Therefore, an alternative gas source is needed and I can be a twin pipes, an additional pipe connection or even a gas supply from another company, which is the solution of the Wu Sha Project.
Conclusion

By going through the Design process of Wu Sha Bridge Crossing Project, the guideline is being set up step by step and the first draft is finished in July 2013.

The Wu Sha Bridge Crossing Project reduced the expenses for the Shunde Gas Company. It, more importantly, increase the design quality and safety level towards bridge crossing design in HKCG. That can benefit to all the bridge crossing projects which will become more favorable due to the update in bridge industry.