A Pilot Project of Introducing the NS-type DIP in Taipei

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ABSTRACT

The water distribution network of the Taipei Water Department (TWD) is very closed to Shanchiao fault. If a severe earthquake occurs, the water supply system for 5 million people in Taipei may be seriously damaged, a full recovery will cost huge amounts of money and time. The ground soil in Taipei Basin is a soft sedimentary layers and has a high underground water table. It's also a high potential soil liquefaction area. Strong earthquakes occur in neighboring areas and Taipei Basin is prone to amplifying ground motion due to a Soft Soil Amplification. Many old distribution pipelines without seismic proof ability may be devastated. In 2011, the magnitude 9.0 Great East Japan Earthquake, resulted in a great damage in the water network, but the new seismic type ductile iron pipe (NS-type DIP) was almost not damaged, because it has better axial displacement capacity and anti- pull off capability at the joint. Because Taiwan does not produce the NS-type DIP, TWD has been importing NS-type DIP from Japan since year 2017, along with establishing guidelines, standards, manuals for design, materials & construction. We have constructed training site specifically for NS-type DIP piping & installing works. TWD has also invited Japanese technicians to train TWD engineers & contractors. And, there are 4,110m pipelines been installed before the end of 2018 (with DN 200 mm and 300 mm). Although NS-type DIP has to rely on imports for the short term; however, TWD is encouraging domestic manufacturers to make investment in NS-type DIP production for reducing costs. Also, government agencies have incorporated NS specifications into CNS national standards to facilitate production for domestic manufacturers.

USE OF SEISMIC PIPES IN JAPAN

After Great Hanshin earthquake (Kobe earthquake) in 1995, Japan started its seismic mitigation policy of waterworks. On Rokko Island in the waterfront region of Kobe City at that time, the SII -type pipeline was already adopted and no disconnection occurred throughout the island, which was a proof of the outstanding seismic feature of earthquake resistant pipes. As a result, the Tokyo Metropolitan Government Bureau of Waterworks started to officially adopt seismic-proof pipes the very next year. After 1995, multiple large earthquakes with a magnitude of 6 and above have occurred throughout Japan. As the frequency of large earthquakes seemed to increase, the Ministry of Health, Labour and Welfare, which is in charge of the water business, prepared in advance and started to promote its seismic policy towards waterworks.

With the promotion of this seismic policy for the water business, the demand for seismic-proof pipes throughout Japan has been increasing each year, too. When calculated by the shipment of the DIP, at the time of the South Hyogo prefecture Earthquake in 1995, seismic-proof pipes only

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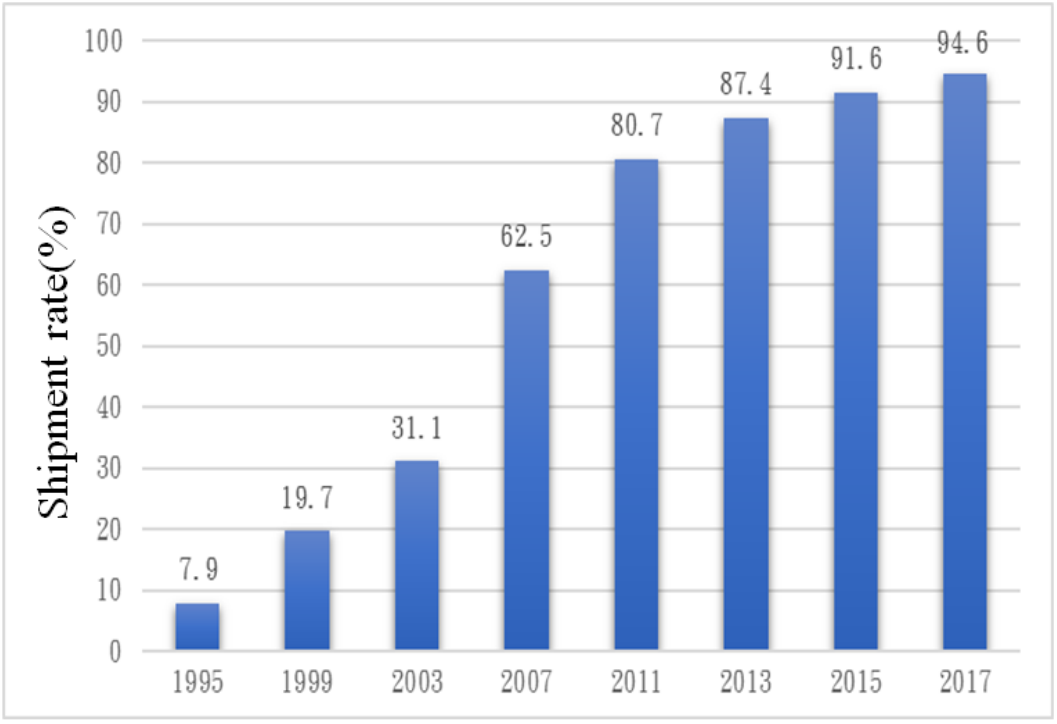
accounted for 7.9%. By 2006, they already exceeded 50%. The ratio in 2017 was up to 94.6%. At present, the seismic-proof joints are widely adopted in DIP and have become quite popular throughout Japan. (Figure 1)



Source: Japan Ductile Iron Pipe Association (JDPA)

Figure 1. Shipment rate of seismic pipes in Japan [1].

The seismic-proof pipes used in Japan are locally produced by Japanese manufacturers and the demand on the domestic market is huge enough to keep the pricing not much higher than that of non-seismic ones. For example, when comparing the pipes of diameter between 100 mm to 300 mm, the price of NS-type DIP is about 1.11 to 1.48 times higher than that of the K-type ones. (Table1). Given the outstanding seismic performance of NS-type DIP, despite the higher prices, they are conducive to the popularity and development of seismic-proof pipes.

Table 1 Comparison in prices of K and NS-type DIP in Japan

Nominal diameter (mm)	K Cement lining	K FBE	NS FBE	NS to K price ratio	
	a	b	c	c/a	c/b
100	6,010	6,578	6,684	1.11	1.02
200	11,980	13,056	15,434	1.29	1.18
300	19,265	22,523	28,472	1.48	1.26

Note: On-going prices are by Japanese Yen per meter in 2018 from Kubota Corporation.

REASONS FOR TAIPEI WATER DEPARTMENT TO INTRODUCE SEISMIC PIPES

In light of the Mei-Nong Earthquake with a magnitude of 6.4 that hit early in the morning of February 6, 2016, the water pipeline was seriously damaged in the region of Tainan and significantly impacted domestic water delivery. In addition to the risks of earthquakes associated with the Shanchiao fault, Taipei has another challenging from its basin geology, which may multiply the damage when an earthquake happens. Also, the formation of Taipei basin is largely mud and sand, which may bring about soil liquefaction during an earthquake, making the entire Taipei Basin a medium to high potential liquefaction level.

The 2011 earthquake, magnitude 9, in East Japan led to serious damage throughout Japan. Many pipes were exposed, suspended, and even ruptured. However, the NS-type DIP with seismic joints stayed nearly intact. The disconnection of water supply was not due to the pipe damage but the transmission power that lost during the earthquake. Due to the relatively mild damage suffered by the NS pipe network system, recovery from the disaster was very quick. Respective bureaus of waterworks in the disaster-hit areas consistently believed that the seismic performance of NS-type DIP contributed significantly to aftermath restoration.

Why are NS-type DIP seismic-proof ? One is their anti-slippage design between pipes that exercise their locking responsibility to sustain in the landslide situation and even sustain without the support of the soil. The other is NS-type DIP are equipped with axial-displacement which allows the energy to be dispersed (Figure 2).

With the above reasons combined, nearly two years after the great Mei-Nong Earthquake, the TWD introduced the NS-type DIP, validated during the great earthquake, to strengthen the pipeline network of Taipei.

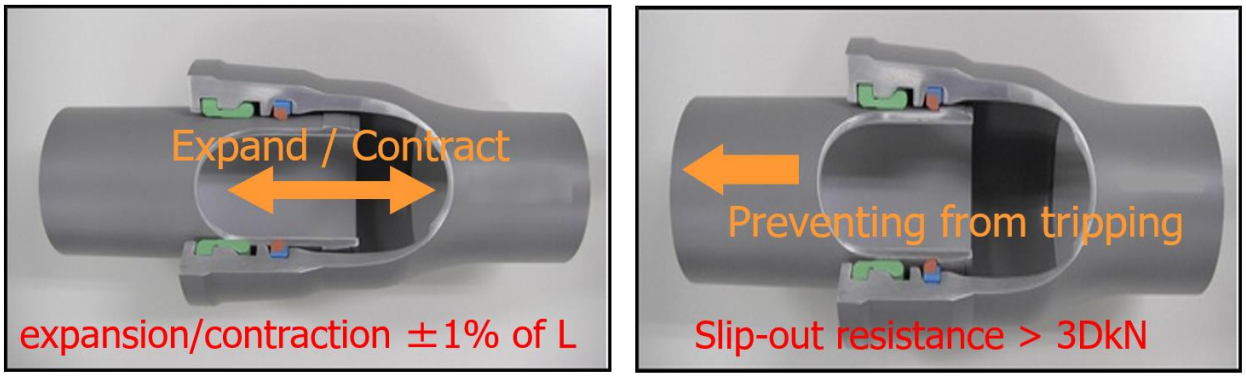


Figure 2 NS trip-proof and retraction

TAIPEI WATER DEPARTMENT INTRODUCES NS-TYPE DIP FROM JAPAN

1. Making Regulations to Govern NS-type DIP

Taiwan does not manufacture NS-type DIP and there were no regulations or specifications at the beginning of the decision of introduction. In this case, TWD hired a consultant company to collect regulations regarding to NS-joint assembling, maintenance and management, and other information including their specifications, prices and materials. With these references, TWD set up its own regulations for NS-type DIP application in Taiwan.

2. The First and Only NS-type DIP Training Site in Taiwan

In hope of initiating NS-type DIP well in Taiwan, TWD have set up a training site at the Zhitan water treatment plant providing not only for TWD staff with hands-on training on piping work profession, but also for many other prospective technicians with certification service. The training site currently accommodates hands-on field operation of pipes with a diameter of 150 mm and 300 mm. (Figure 3).

Figure 3 NS-type DIP training site at Zhitan water treatment plant

3. Training for NS-type DIP

For the NS pipe training, different programs are planned for work supervision and the pipe assembling of the TWD. The training for the staff at the TWD focuses on helping the students understand the design of NS pipe and the basic construction ideas so that they can precisely supervise the construction performed by the contractor in the field. The training for field construction staff focuses on helping the students get completely familiar with the NS pipe assembling techniques and concepts so that they can perform correct construction in the field.

4. Implementing NS-type DIP in Taiwan

In this pilot program, the NS-type DIP were purchased from Kubota Corporation by a Taiwanese local company, Shin Nan Casting Factory Co., LTD. authorized by TWD. All the pipelining work was conducted by a domestic contractor and all the construction staff had completed NS-type DIP training and had been certified with work permit before on-site construction.

For the site selection, TWD took reference based on Japan Seismic Pipes Applicability Principles and chose a DMA as the trial region because of its location being in a high potential liquefaction area

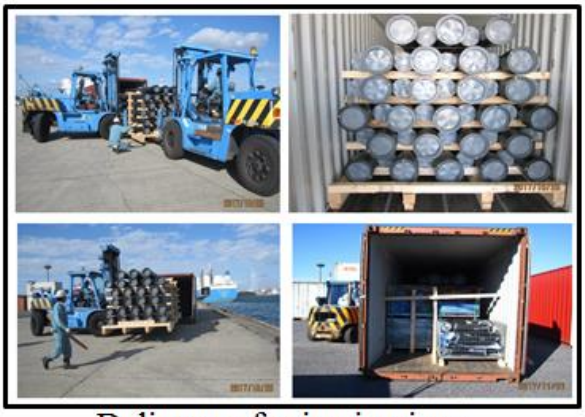
and close to a Disaster Prevention Park (emergency shelter), meeting up all the criteria specified. (Figure 4).

The Taipei Water Department initiated the pipelining of the NS pipe on November 15, 2017. Judging from the restricted space available for field excavation and the interference from the existing underground pipelines, which both highly burden the field construction, we invited professionals from Japan to co-work with our staff, equipped with NS Type professional skills, in the first month of the trial program. The Japanese and Taiwanese staff exchanged with each other during construction and resolved problems encountered during the process.

One year after, TWD again invited Japanese technicians for on-site guidance for a month. During the month, our construction staff learned further from the Japanese professionals and based on their previous one-year experience, they proposed to optimize the pipe cutting device, which was well appreciated among the Japanese technicians.

During the two visits by the Japanese technicians, they pointed out pending improvements at the construction site. Therefore, TWD also held two meetings where participants could exchange their feedback about the construction accordingly to enhance the quality of construction (Figure 5).

The trial project was completed in November 2018, including 3,630 meters of pipes with a diameter of 200 mm implemented, and 480 meters of pipes with a diameter of 300 mm implemented. A total of 4,110 meters of the NS-type DIP are in use.



Delivery of seismic pipes

The selected trial site

Japanese technicians on the trial site

Construction in process

Figure 4 NS-type DIP delivered from Japan and their professional on-site guidance

Figure 5 Japanese technicians on-site guidance

STRATEGY FOR PROMOTING NS-TYPE DIP

1. Having Risk Map for NS-type DIP Implementation

Due to the fact that NS-type DIP are not available in Taiwan, for the short term, importation from Japan is the only option. As a result, the purchase cost will be much higher than that of the non-seismic resistant pipelines. With limited budget, we cannot replace all the pipes with NS-type DIP in one time. In order to make the best of our limited budget, we made priority for replacement based on the criteria including Site Effect, Soil Liquefaction Potential, pipeline susceptibility to damage, and their population density. Therefore, we teamed with the National Center for Research on Earthquake Engineering for pointing out the areas that meet the demand for NS-type DIP. (Figure 6).

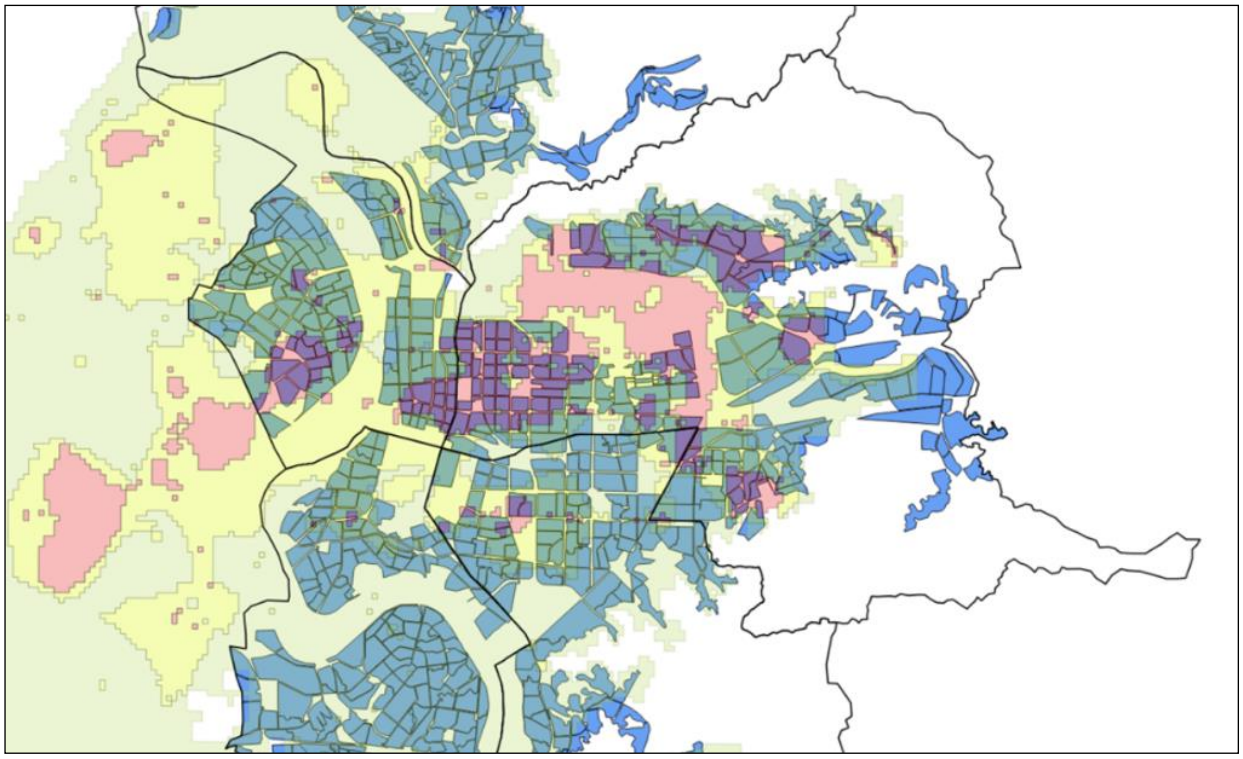


Figure 6 Priority replacement of NS-type DIP in Taipei Area

2. Encouraging Domestic Manufacturers for NS-type DIP

To bring down the cost of NS-type DIP implementation, it has to be manufactured locally. To encourage the local manufacturers, TWD will be increasing the demand gradually. TWD is now revising the regulations in CNS 10808 with reference of JIS G5526:3014 to help our local business manufacture the pipes. Once completed, it will further help local manufacturers for production.

3. Establishing Educational Trainings and Certification Systems

In order to maintain the optimal quality of construction, TWD is authorizing an international consultation company for establishing a sound training program and certification system. At the current stage, we offer our contractor with the training for their construction staff. All the NS-type DIP implementation in Taipei will be carried out by our certified technicians only.

However, for a long term, TWD is hoping to establish its a certification and training system for Taiwan. The Chinese Taiwan Water Works Association (CWWA) will organize educational training for construction staff and perform hands-on tests. Those having been approved through the tests will receive a qualified certificate and construction staff with a qualified certificate may engage themselves in the engineering involving seismic pipes in Taiwan. (Table 2)

Table 2 Short-term and Long-term plan for NS-type DIP Training and Certification

	Educational training	Certification
Short-term plan	TWD authorizes an international consultation company for providing contractor with the training for their construction staff.	Work permit is issued and valid only during the contract period in Taipei
Long-term plan	CWWA organizes training for the technicians interested in NS-type DIP	Certification is applied to NS-type DIP implementations in Taiwan

CONCLUIONS AND SUGGESTIONS

1. Although there are quite a few other seismic pipes available, NS-type DIP remains a suitable option for Taiwan, where earthquakes are usual, for the reasons including the expired patent period, real-event earthquake proved its performance and the adoption by Los Angles.
2. By copying the successful model in driving the SSP (Stainless Steel Pipe) industry in Taipei, the length of construction is made available steadily each year. The local demand drives supply and urges manufacturers to invest in the production, bringing down the cost.
3. The seismic performance of NS-type DIP relies not only on the material but also the precision of pipelining works. For the early stage of promotion, the focus will be placed on training contractors in Taipei. Later, the training will be provided by the CWWA and the certification system of Taiwan will be established.
4. Given the insufficient production available from local manufacturers, for the early stage, the supply relies on importation from overseas. Due to the high prices, however, high disaster potential areas shall be prioritized by research.