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THE HOT BRANCHING TECHNIQUE WITHOUT SHUT-OFF DEVICE FOR STEEL PIPE AND DUCTILE IRON PIPE

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1 . ABSTRACT

In Japan, the traditional hot branching technique takes much time and is expensive. As a consequence, it harmfully impacts the environment. The reason lies in the fact that first this technique needs the installation of a by-pass line with gas stoppers. But, it is also needed to cut the pipe and to insert a branch joint. Moreover, the evacuation of a large volume of excavated soil can be the cause of traffic jams. Indeed the needed excavation pit's dimension is about 13 feet long. And finally, the urban underground congestion is also problematic for the gas branching construction activity.

In order to remove some of these problems and create more environmentally-friendly construction, we developed the new hot branching technique. This shortens the construction time, reduces costs, and limits excavation volume. The technique is carried out with a specialized hot tapping tool and a special joint named "SSB". "SSB" is the abbreviation for "Service Sleeve Branch joint ". It includes a plate that works as a gas shut-off device. The plate eliminates the need for an expensive gas shut-off device (non-blow shutter unit) . Furthermore this technique reduces the needed excavation pit's dimension to just about 3 feet long. It means that this is by 75% smaller.

The technique is used for steel pipe and ductile iron pipe with diameters ranging from 4 inches to 10 inches. Last advantage, by using SSB as a transition joint, the branch main can be renewed to polyethylene pipe.

As a matter of fact, nowadays the new branching technique is widely used, and is adopted by 59 regional gas companies in Japan. So about 550 joints are installed every year.

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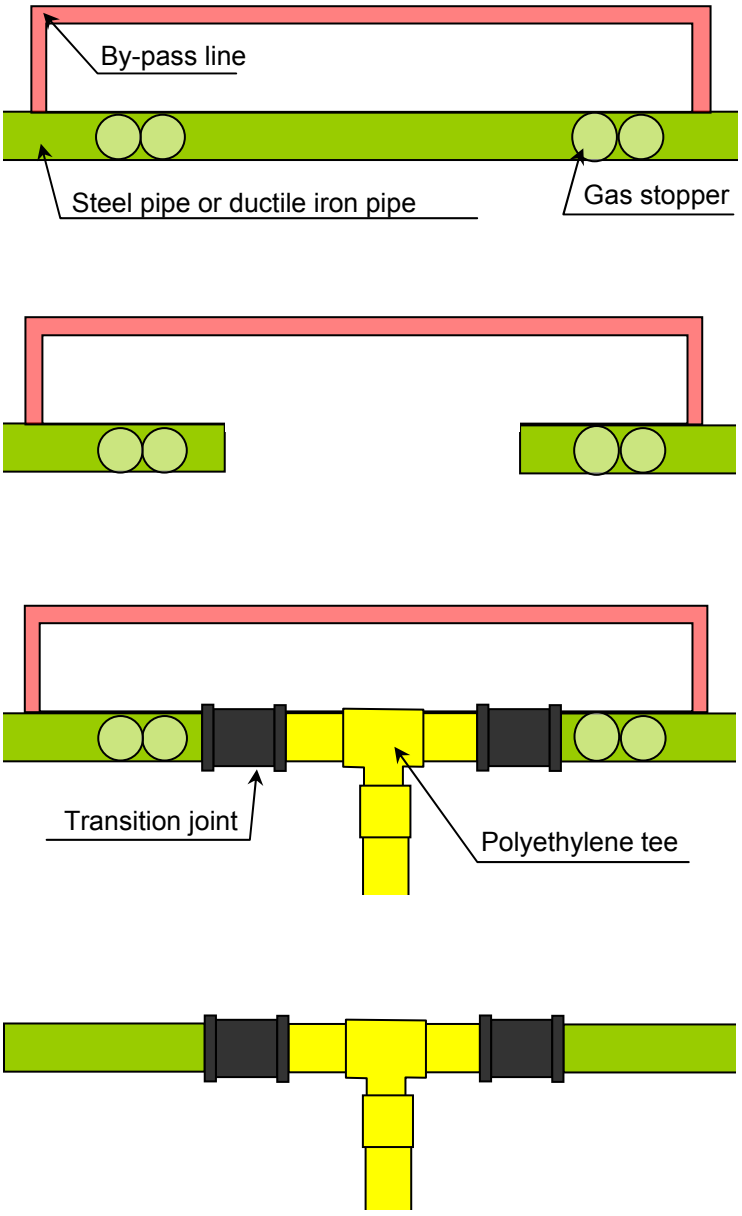
2 . BODY of PAPER

2.1 Background of development

In Japan, the traditional hot branching technique needs to cut the pipe and insert a branch joint after installing a by-pass line and setting gas stoppers (Figure 1). Therefore, the needed excavation pit's dimension is about 13 feet long. As a result, it is time consuming and expensive. In addition, the larger excavation causes traffic problems to both pedestrians and vehicles. Finally, the existing underground pipe congestion may also be the source of many difficulties for gas branching activity. All of these are harmful to the enviroment.



①Install a by-pass line and set gas stoppers on existing pipe.

②Cut the existing pipe to branch with a polyethylene tee.

③Install a polyethylene tee with transition joints.

④Remove a by-pass line and gas stoppers.

Figure 1 : Procedure of the traditional hot branching technique

As an answer to constraints, we developed the new hot branching technique that enables to shorten construction duration, to reduce costs, and to limit excavation volume. This technique does not request any cutting of the pipe and nor installation of a branch joint with by-pass line and gas stoppers. The needed excavation pit's dimension is only about 3 feet long.

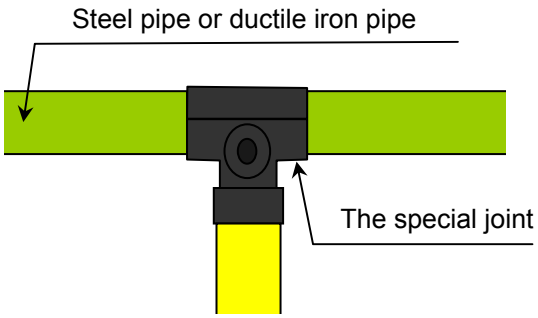


Figure 2：The new hot branching technique

2.2 Summary of development

2.2.1 Composition of the development products

The specialized hot tapping tool (Figure 3) and the special joint named SSB (Figure 4) are used for the new hot branching technique. "SSB" is an abbreviation of "Service Sleeve Branch joint ".

This tool is common for steel and ductile iron pipe. The joints for steel pipe are different from the joint for ductile iron pipe. Because they have different outside diameters.

Figure 3：The specialized hot tapping tool

Figure 4：The specialized joint "SSB"

2.2.2 Application scope of SSB

Table 1 shows the application scope of SSB. SSB can branch steel pipe and ductile iron pipe with diameters ranging from 4 inches to 10 inches. In addition, it is possible to branch the pipe by the top and by the bottom with 45 degrees inclination. This is very useful in highly congestion underground environment.

Table1:Application scope of SSB

Material of main	Steel pipe and ductile iron pipe
Material of branch pipe	Polyethylene pipe
Main diameter × branch pipe diameter	4”×4”、6”×6”、8”×8”、10”×10”
Operating pressure	Use up to 30mbar
Branching angle	Top and bottom 45 degrees

2.3 Feature of development

2.3.1 Feature of SSB

SSB includes a plate that works as a gas shut-off device. Moreover, the swarf after having bored the existing pipe can be collected. The plate eliminates the need for gas shut-off device (non-blow shutter unit) and associated equipment. It is located in the bottom part of SSB as shown in Figure 5. In addition, we succeeded in producing low cost SSB. In fact, the structural design of SSB and the simplicity of the circular plate are the key reasons for low cost production. As a result, we have a tool with a reduced initial investment cost and a simplified work process.

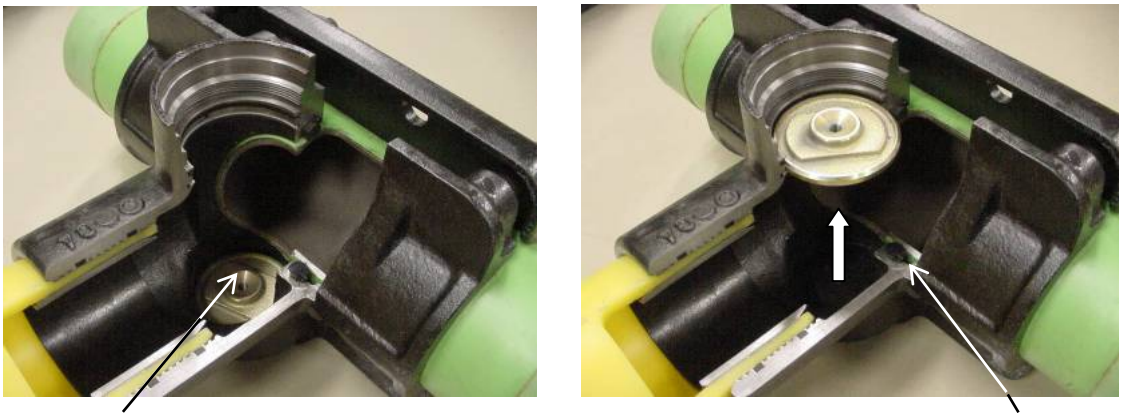
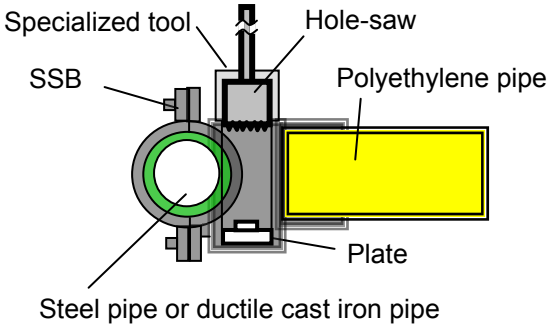


Figure 5：Cross-section of SSB

2.3.2 Procedure of the new hot branching technique

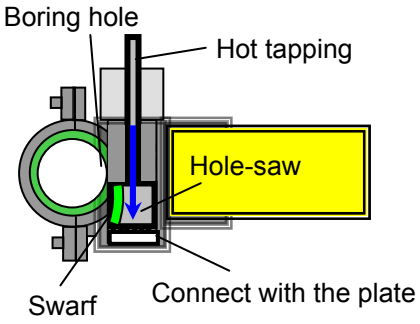
Procedure of the new hot branching technique is shown in Figure 6.



(1) Install SSB in the steel pipe or ductile cast iron pipe.

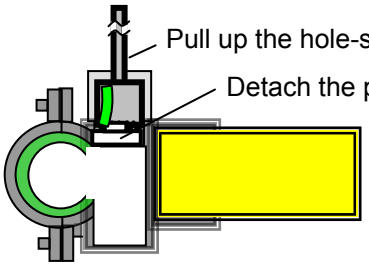
(2) The polyethylene pipe on the branch side is connected.

(3) Screw in the specialized hot tapping tool at SSB.



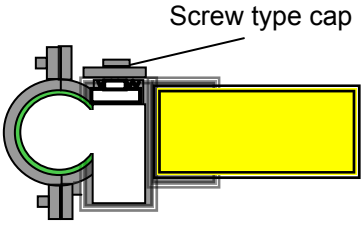
(4) Boring hole with the specialized hot tapping tool.
It takes only about 5 minutes when the caliber of the pipe is four inches.

(5) Connect the plate with the hole-saw which has a swarf after having bored the existing pipe.



(6) Pull up the shaft and fix the plate at the upper part, it is possible to prevent a gas spouting.

(7) Detach the plate from the hole-saw. The plate comes off when the hole-saw is turned counterclockwise. Because it is screwed to the hole-saw.



(8) Remove the specialized hot tapping tool from SSB.

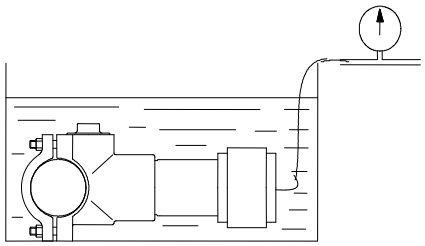
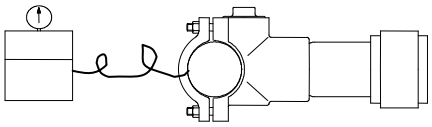
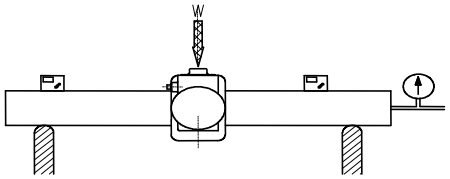
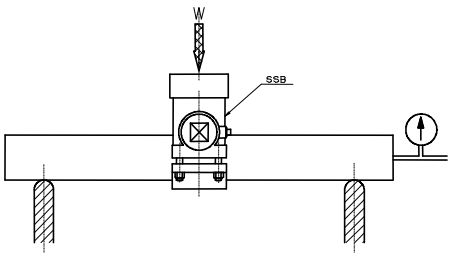
(9) Take out swarf from SSB.

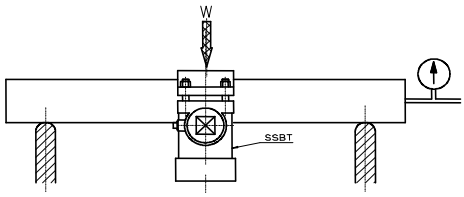
(10) Screw in the cap.

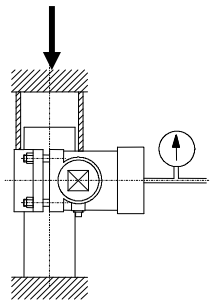
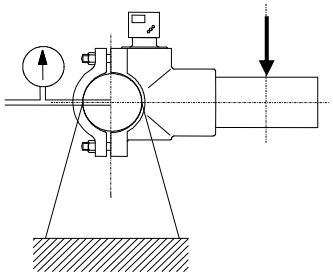
Figure 6：Procedure of the new hot branching technique

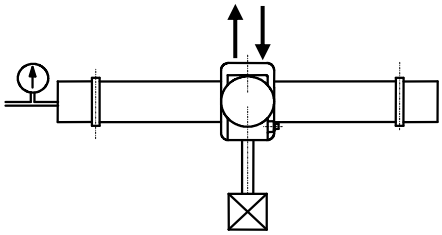
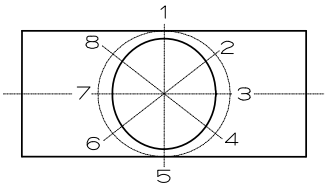
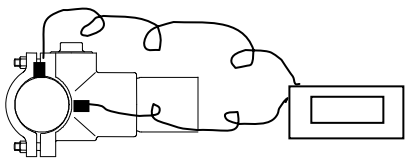
2.4 Performance confirmation

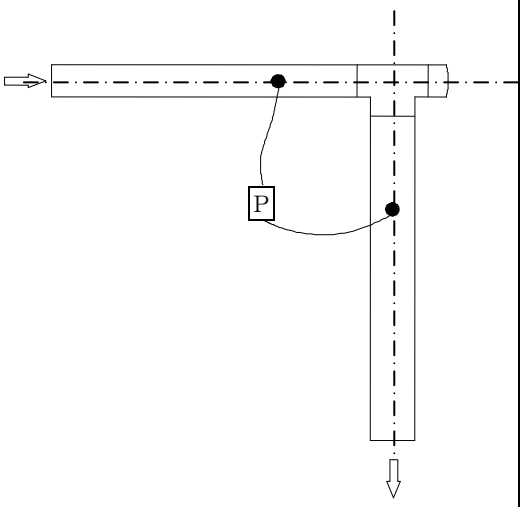
SSB was checked by the following qualification test, and performance on practical use is good.
Notice : No entry for ten inches of ductile iron pipe.

<table>
<tr><th colspan="2">Items</th><th>Conditions of test</th><th>Test result</th></tr>
<tr><td>1</td><td>Air tightness test</td><td> 
(1) Test pressure : 0.11MPa
(2) Holding time : 24 hours</td><td>No leak.</td></tr>
<tr><td>2</td><td>Hydraulic test</td><td> 
(1) Hydraulic pressure : 0.15MPa
(2) Holding time : 24 hours</td><td>No leak.</td></tr>
<tr><td rowspan="2">3</td><td>Bending test
3-1 From the upper side</td><td> 
(1) Test pressure : 0.1MPa
(2) Distance between fulcrums
[Steal pipe]
4 inches : 1,000mm
Over 5inches : 1,500mm
[Ductile cast iron pipe]
All size : 2,000mm
(3) The load is the maximum when leakage occurs.</td><td><table><tr><th rowspan="2">Main (Diameter)</th><th colspan="2">Load</th></tr><tr><th>Ductile</th><th>Steel</th></tr><tr><td>4 inches</td><td>90 kN</td><td>75 kN</td></tr><tr><td>6 inches</td><td>180 kN</td><td>150 kN</td></tr><tr><td>8 inches</td><td>210 kN</td><td>280 kN</td></tr><tr><td>10 inches</td><td>—</td><td>480 kN</td></tr></table>It is able to confirm that bending strength of SSB is equal to the modulus of rupture of the pipes by this test result.</td></tr>
<tr><td>3-2 From the branch side</td><td> 
The condition of the test is a ditto.</td><td><table><tr><th rowspan="2">Main (Diameter)</th><th colspan="2">Load</th></tr><tr><th>Ductile</th><th>Steel</th></tr><tr><td>4 inches</td><td>160 kN</td><td>65 kN</td></tr><tr><td>6 inches</td><td>220 kN</td><td>115 kN</td></tr><tr><td>8 inches</td><td>370 kN</td><td>185 kN</td></tr><tr><td>10 inches</td><td>—</td><td>350 kN</td></tr></table>The result of the test is a ditto.</td></tr>
</table>

<table>
<tr><th colspan="2">Items</th><th>Conditions of test</th><th>Test result</th></tr>
<tr><td>3</td><td>Bending test
3−3 From opposite of the branch</td><td> 


The condition of the test is a ditto.</td><td>
<table>
<tr><th rowspan="2">Main (Diameter)</th><th colspan="2">Load</th></tr>
<tr><th>Ductile</th><th>Steel</th></tr>
<tr><td>4 inches</td><td>70 kN</td><td>70 kN</td></tr>
<tr><td>6 inches</td><td>150 kN</td><td>120 kN</td></tr>
<tr><td>8 inches</td><td>230 kN</td><td>230 kN</td></tr>
<tr><td>10 inches</td><td>—</td><td>400 kN</td></tr>
</table>
The result of the test is a ditto.</td></tr>
<tr><td>4</td><td>Strength to slide</td><td> 
(1) Test pressure : 0.1MPa
(2) The load value is the maximum when leakage occurs.</td><td>
<table>
<tr><th>Main (Diameter)</th><th>Ductile</th><th>Steel</th></tr>
<tr><td>4 inches</td><td>40 kN
29 mm</td><td>30 kN
22 mm</td></tr>
<tr><td>6 inches</td><td>80 kN
45 mm</td><td>50 kN
35 mm</td></tr>
<tr><td>8 inches</td><td>75 kN
40 mm</td><td>40 kN
35 mm</td></tr>
<tr><td>10 inches</td><td>—</td><td>65 kN
38 mm</td></tr>
</table>
Upper case character is the load value (kN). Bottom case character is the axial displacement (mm).</td></tr>
<tr><td>5</td><td>Strength to rotation</td><td> 
(1) Test pressure : 0.1MPa
(2) Load-point : 500mm
(3) The load value is the maximum when leakage occurs.</td><td>
<table>
<tr><th>Main (Diameter)</th><th>Ductile</th><th>Steel</th></tr>
<tr><td>4 inches</td><td>7 kN
29°</td><td>3 kN
22°</td></tr>
<tr><td>6 inches</td><td>9 kN
45°</td><td>6 kN
24°</td></tr>
<tr><td>8 inches</td><td>11 kN
40°</td><td>8 kN
20°</td></tr>
<tr><td>10 inches</td><td>—</td><td>12 kN
30°</td></tr>
</table>
Upper case character is the load value (kN). Bottom case character is the angle of rotation (°).</td></tr>
</table>

Items		Conditions of test	Test result
6	Strength to vibration	 (1) Test pressure : 0.1MPa (2) Amplitude value : ±2mm (3) Frequency : 3Hz(150,000 times) (4) Distance between fulcrums All size : 2,000mm	No leak.
7	Heat cycle	(1) Test pressure : 0.1MPa (2) Temperature conditions of temperature controlled bath. -5°× 3 hour →60°× 3hour (Travel time is 2 hour.) (3) Frequency : 50 times (4) After the heat cycle test, the tightness leak test is done.	No leak.
8	Seal performance (Rubber ring) 8-1 Short-term pressure distribution.	Short-term pressure distribution is measured by exclusive film.  	1) Short-term pressure distribution is between from 7.8Mpa to 12.7Mpa. 2) There is no problem in use in a short-term. The reason lies in the fact that seal performance is higher than the working pressure range.
	8−2 Long-term pressure distribution.	Long-term pressure distribution is measured by pressure sensor.  [Accelerated test condition] (1) Temperature conditions of temperature controlled bath are 23°. (2) Holding time is 1,000 hour.	1) After 1,000 hour, long-term pressure distribution is 5.9Mpa or more. 2) It is 4.9Mpa or more in assumption for 50 years. 3) There is no problem in use in a long- term. The reason lies in the fact that seal performance is higher than the working pressure range.

<table>
<tr><th colspan="2">Items</th><th>Conditions of test</th><th>Test result</th></tr>
<tr>
<td>9</td>
<td>Pressure drop</td>
<td>



(1) Primary pressure is 2.5kPa.
(2) The test is executed by the maximum design flowing quantity.
<table>
<tr><th>Main (Diameter)</th><th>maximum flow</th></tr>
<tr><td>4 inches</td><td>55 m^3/h</td></tr>
<tr><td>6 inches</td><td>159 m^3/h</td></tr>
<tr><td>8 inches</td><td>353 m^3/h</td></tr>
<tr><td>10 inches</td><td>550 m^3/h</td></tr>
</table>
</td>
<td>
<table>
<tr><th rowspan="2">Main (Diameter)</th><th colspan="2">Pressure drop</th></tr>
<tr><th>Ductile</th><th>Steel</th></tr>
<tr><td>4 inches</td><td>16 Pa</td><td>8 Pa</td></tr>
<tr><td>6 inches</td><td>20 Pa</td><td>13 Pa</td></tr>
<tr><td>8 inches</td><td>29 Pa</td><td>18 Pa</td></tr>
<tr><td>10 inches</td><td>—</td><td>34 Pa</td></tr>
</table>
The pressure loss of each size is very small.
</td>
</tr>
</table>

2.5 Advantageous effect

2.5.1 Preservation of the environment

The needed excavation pit's dimension of the traditional hot branching technique is about 13 feet long as shown in Figure 7. However, the new hot branching technique is able to limit excavation volume. Concretely, the excavation area is reduced by about 75%, and there is an approximately 75% reduction in the volume of excavated soil, which has to be handled as industrial waste as shown in Figure 8. Through these cuts, the new technology contributes to preserve the environment.

Figure 7：Picture of the traditional hot branching technique

Figure 8：Picture of the new hot branching technique

2.5.2 Shortening of construction time

This branching process takes only about 3~4 hours. It is about 50% of the time which is required for the traditional hot branching technique . The reason lies in the fact that the new hot branching technique does not need to install a by-pass line and gas stoppers. Therefore, the excavation area is smaller, and the construction time shortened.

2.5.3 Improvement of the safety level

The new hot branching technique is able to branch the pipe without any leakage by using the specialized hot tapping tool. It eliminates the need for gas shut-off device (non-blow shutter unit) and all associated equipment. As a result, using this new technique can prevent risks of accidents that occur during construction. Thereby the safety level is improved. It also means a reduced initial investment cost and a simplified work process.

Figure 9：The sight of work

(Boring hole with the specialized hot tapping tool)

2.5.4 Reduction of construction costs

The construction cost is 63% lower compared to the traditional hot branching technique as shown in graphs below. These calculations are estimations based on Keiyo Gas experience.

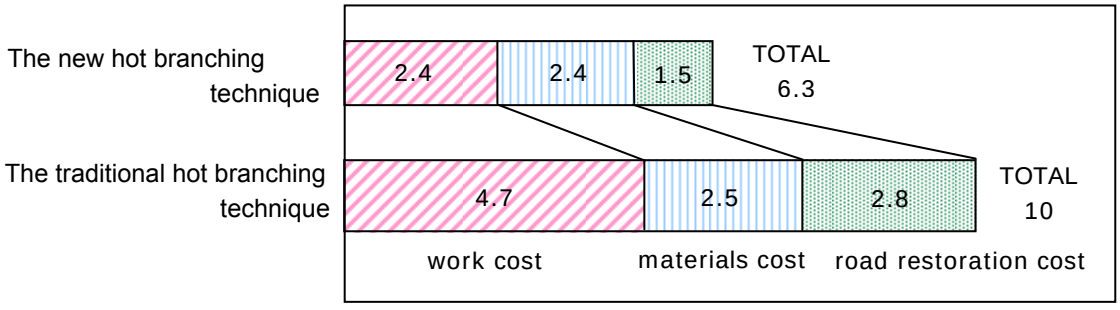


Table2： Construction cost comparison

(When assuming that the construction cost of the traditional hot branching technique is 10)

3 . LIST of TABLES

4 . LIST of FIGURES