58

# BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

## CEMENT AS A SUBSTITUTE FOR LEAD IN JOINTING C. I. PIPES

Lead is the conventional jointing material for cast iron pipes and this being a soft metal, apart from offering a strong water-tight joint, withstand linear movements and deflections of pipes under various circumstances. Hence it has been the unchallanged only jointing material in the last several decades. This method of jointing involves the use of lead, either poured and caulked, or formed with fibrous lead packing or with lead rod. But the present foreign exchange difficulties has imposed a tremendous cut in the import of lead and consequent short supply of the same for jointing purposes. Naturally the engineers mind now is focussed on all possible alternatives and their relative merits and demerits. These alternatives are, sulphur compounds, cement mortars, bitumen compounds with various filler materials, cement mortars with reinforcements and rubber gaskets. Brief descriptions of these alternates are given below.

### 1. Bitumen-cement mixtures

Combination of bitumen emulsion with portland cement yields an interesting mixture intermediate between the properties of asphalt and cement mortar. It makes a highly workable mixture when freshly mixed and should be very resistant to percolation. Not all grades of bitumen emulsion can be gauged with cement, but most manufacturers of such products supply a suitable liquid. The mixture is easily made, the emulsion being used instead of water for gauging the mortar, with cement : sand ratio of 1:2. It gives firm adhesion and slight plasticity.

### 2. Rubber latex with cement

It is reported to give good adhesion to a variety of surfaces, such as metals, brick and concrete. A distinct elasticity is present. The proposed mix is 2 parts (by weight) of rubber latex, 6 parts of cement and 1 part of cork.

### 3. Poured filling of bitumen

It is applicable only for drainage purposes under atmospheric pressure.

### 4. Sulphur Compounds

These are mixtures of sulphur, silica etc., and are obtained as black powder or cake. The compound has to be melted on the job and poured into the joint in a manner similar to lead pouring. It is recommended that hemp yarn be used rather than tarry or oily materials. The light weight and avoidance of caulking may make them more competitive. But sulphur fumes cause considerable trouble. The joints of these materials initially 'leak' or 'sweat' but tighten up in a short time. Since these joints are rigid, they should not be used to connect a newly laid line to an old line, as the settlement of new line will cause failure. Only lead joints should be used in such cases.

Majority of the joint failures were reported to be circumferential break, associated with localised corrosion. Though the temperature stresses alone are insufficient to cause failure, when combined with other stresses induced by either beam or cantilever action, failures do occur. The seasonal soil changes, also have a direct bearing on pipe failure. An ideal sulphur compound may have about 60% of sulphur and about 38% of graded silica (for tensile strength) and other additives 0.5% of carbon, 1% of plasticizer (thiakol), 0.6% Bactericide (Sodium Silicafluoride) and 0.1% of phosphorous pentasulphide. The plasticizer offers ductility to the joint and the bactericide prevents the attack by sulphur bacteria. Even highly plasticised compounds are available. Water soluble bactericide should not be used as they will be leached out. Pitting of the pipe at the spigot and even at the bell extending inside the joint where the packing started was observed with sulphur compound joints where the soil was damp. Under similar conditions splitting of the bell was also observed. Failure due to crumbling and disintegration of the compound shortly after laying of the lines, was also common.

Even with the plasticized compounds the following types of failures are reported in literature.

(a) Circumferential breakage of spigot directly adjacent to the joint.

(b) Longitudinal splitting of bell.

(c) Band of deep corrosion encircling the pipe at that point on the spigot where the first contact is made with sulphur cement and in turn develop a notch.

(d) Severe corrosive attack on the iron adjacent to jointing material.

Hence these sulphur compounds are recommended unless unavoidable.

## 5. Flanged joints (without gasket)

The two flanges of either pipes are connected by bolts and nuts through the holes in the flanges. The water tightness of the joint depends upon the finishing of the flanges.

## 6. Mechanical joints

This has a ring which, when the bolts are tightened, compresses the rubber gasket to make a tight fit. while tightening the joint 25 lbs. to 50 lbs. pull on the 10″ wrench is recommended. For effective sealing, the surface with which the gasket comes into contact are brushed thoroughly with wire brush prior to assembly and further brushed with soap water, also on the rubber gaskets.

**Bolt torque**

| Size | Range of torque in ft-lbs. | Length of wrench |
|---|---|---|
| 5/8″ | 40-60 | 8″ |
| 3/4″ | 60-90 | 10″ |
| 1″ | 70-100 | 12″ |
| 1½″ | 90-120 | 14″ |

Plain rubber gaskets are standard for these joints, where temperature is not deleterious to gasket. These joints are satisfactory from the point of view of flexibility, convenience, safety, economy and ease of maintenance. But forgetting to place the gaskets, bolts being omitted or left loose are common. As bolts being broken due to overtightening was common, torque limiting wrench had been reported to be useful.

## 7. Roll-on joints

A rubber gasket is inserted in a specially grooved bell and a lubricant is applied to it. The spigot is then forced into the bell and the joint is complete. These joints are commercially known as Tyton, All-tite, bell-tite or fastite and require no lead, yarning or caulking. Deflection at the joint is possible to form curves and jointing proceeds rapidly. The joint may be assembled under wet trench conditions also. The joint is not strong longitudinally. Blocking or anchoring is especially necessary at all changes of direction. The synthetic rubber is much superior to natural rubber as it withstands the aggressive soil action, microbiological disintegration and offers uniform and homogeneous cross-section. The cross section of these rings vary from circular to any specific shape suiting the groove in the bell. The corrugation in the arched base (preferably wider than the top) offers firm grip. The gasket locks into the place and does not roll on the spigot end of the pipe. In general, the principle of all these joints is the same. Hence the variations in different types are all in the design of bell and gasket, and the varying hardness of the rubber gasket as measured by durometer. Actually this is the best form of jointing cast iron pipes

## 8. Cement joints

The various combinations of cement mortars are reported to be made use of, for making joints in cast iron pipes. It is reported that the sand cement mortar (1 : 1) joints form poor line when compared to lines with joints of cement only. The simplicity and efficiency of the joints with cement alone are high enough to make it competitive with other types of cement-sand mortar joints. The details of the cement mortar joint is as given below :

(i) The joint is first yarned with hemp yarn dipped in the cement slurry. The yarn is first inserted for about 1½″ depth and well pressed in the same manner as for the lead jointing.

(ii) Sufficient cement for one joint is placed in a pan.

(iii) Water is sprinkled on cement until it is wet enough to mould and it also should be dry enough to crumble when dropped from a height of about 12″ (300 mm).

(iv) Cement mortar should be rammed into the joint by caulking tools.

(v) For half of the depth it is done so and then caulked as hard as possible.

(vi) The filling is completed and the cement is caulked again.

(vii) After 16-24 hrs. the pressure can be allowed in the water main. Filling the pipe without pressure after 4 hrs. is advisable.

(viii) Initially the cement joints may sweat for sometime but will soon close up. For final test, the completed joint when struck with a hammer should give a metallic ringing sound.

(ix) Use of lead joint at an interval of 500 ft. is advisable.

(x) After jointing moist earth or wet sack should be used to cover the joint.

Note:—A joint should not be caulked until five or six lengths of pipe have been laid beyond it. These joints used in Western countries 50 years back are still working satisfactorily.

In colder climates a small amount of $Ca\ Cl_2$ (about 2%) may be added to the cement mortar to accelerate the setting. But in warmer climates it is forbidden to use, as it produces excessive heat and especially so when mixing is not uniform.

## Discussion

Out of the above eight alternates the sulphur compound had been considerably used in the past in U.S.A. But the experiences are discouraging. The corrosion, fume, and possible leakage due to inability to caulk are main drawbacks. Bitumen cement, poured filling of bitumen and rubber latex joints are of temporary nature and can be effectively used in emergency and in active war area where flexibility in joints is required to withstand the high vibrations. In case of flanged joints slightest bad workmanship would result in considerable and continuous leakage. In mechanical joints the failure of bolts and gaskets are common. The roll-on joints are weak in longitudinal pull. Also with a pipe of one manufacture, a specific type of gasket must be used. This becomes a great handicap in cases of emergency repairs in due course, by which time the company may change the shape of the gasket and corresponding groove in the pipe. The natural rubber gaskets are suceptible to bacterial and chemical attacks. The synthetic rubber is very costly. Further, the flanged, mechanical and roll-on joints are costlier than lead joints. Therefore it appears that cement joints offer a very economical and feasible application for jointing Cast Iron pipes and to confirm this, certain investigations were carried out at the CBRI.

## Work carried out at Central Building Research Institute

Joints in C.I, pipes were made as specified above and tested for hydrostatic load. The results of these investigations are given in table I. It is clearly seen from table I that these joints can easily take a pressure upto 200 psi., 16 hours after making the joint. Though a water cement ratio of 0·22 had given a better strength but a ratio of 0·25 had to be adopted from workability point of view in field. This change had been adopted mainly in view of extending the laboratory tests to the field condition. Least possible water cement ratio is recommended to avoid shrinkage.

**Table I**

| S.No. | Joint specification | Time lapse after jointing and before testing | Details of water curing | Failure pressure |
|---|---|---|---|---|
| 1. | Cement mortar joint, using cement only with water cement ratio of 25% | 22 days | 7 days | 250 psi |
| 2. | Cement mortar joint, using cement only with water cement ratio of 30%. | 20 days | 7 days | 280 psi |
| 3. | Cement mortar joint, using cement and fine sand 1:1 and with water cement ratio of 33·4%. | 24 days | 7 days | 270 psi |
| 4. | Cement mortar joint, using cement and 2·5% calcium chloride with water cement ratio of 25%. | 24 hours | 16 hours | 450 psi. |
| 5. | Cement mortar joint, using cement and 2·5% calcium chloride with water cement ratio 25%. | 8 hours | 4 hours | 400 psi. |
| 6. | Cement mortar joint, using cement only with water cement ratio of 25% | 23½ hours | 16 hours | 230 psi. |

A test was conducted to find the ability to withstand a possible beam or cantilever behaviour of the pipe with cement joints. A clear span of 6′ length of pipe, with a cement joint at the centre, along with an internal hydraulic pressure of 100 psi was loaded at centre till failure. The results are given in table II. For comparison a lead joint was also tested and the result is shown in the table.

**Table II**

| Sl. No. | Dia. of pipe | Type of joint | Clear span | Load at which the joint failed W | Remarks |
|---|---|---|---|---|---|
| 1. | 4″ | Cement mortar | 6′ | 0·7 tons | Leakage was in drops upto 2·5 tons. |
| 2. | 4″ | ,, | 6′ | 1·1 tons | Leakage was in drops upto 3·5 tons |
| 3. | 4″ | ,, | 6′ | 1·2 tons | Leakage was in drops upto 4 tons. |
| 4. | 4″ | ,, | 6′ | 1·25 tons | Leakage was in drops upto 3 tons. |
| 5. | 4″ | ,, | 6′ | 1·2 tons | Leakage was in drops upto 3 tons. |
| 6. | 4″ | ,, | 6′ | 1·0 tons | Leakage was in drops upto 3 tons. |
| 7. | 4″ | lead joint | 6′ | 0·5 tons | Leakage was continuous |

### Test for dynamic vibration and field condition

One 4″ dia. C.I. pipe line having two cement mortar joints was laid 2′-6″ deep in the ground across a road. After 24 hours, water pressure upto 100 psi was given, no decrease in the water pressure was observed. Afterwards a loaded truck was used to give the dynamic load on the road above the joints but there was no loss of pressure. Dropping of 50 lbs. concrete block from a height of 10 ft. on the road above joints were repeated several times with no loss of pressure. At intervals of two months a water pressure of 100 psi was given successfully to this exprimental line. Now even after 8 months the line is without any signs of failure.

### Cost economics

In case of a 4 in. dia C.I. pipe the cost of cement mortar joints is about Rs. 4/—per joint, whereas lead joint costs about Rs. 20/—Hence the economy achieved is considerable by adopting the cement joints.

### Conclusions

The cement joint appears to be most competitive economic and suitable alternate for lead in joining the C.I. pipes. No doubt from flexibility and convenience point of view the rubber gaskets appear to be the final answer. But the cost for this is very high and a particular type of gasket can be used only with the specified type of pipe manufactured by the same company. While laying the pipe with cement mortar joints, where ever the soil is not firm, a suitable bedding or foundation in the trench as desired by the local authority must be given. Though it is observed that these joints take considerable load, a reliance can be made only as a factor of safety and the joints must be relieved of any possible strain due to settlement.

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