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WAA Sewers and Water Mains Committee: Materials and Standards

Information and Guidance Note

GUIDE TO JOINT DESIGN AND INSTALLATION OF PVC WATERSTOPS IN WATER RETAINING STRUCTURES

FOREWORD

This guide has been prepared by a Liaison Group under the direction of the Water Authorities Association Sewers and Water Mains Committee with membership drawn from both Water Industry and relevant UK manufacturers. It complements Information and Guidance Note No. 4-31-02, Specification for Plasticised PVC Waterstops for use in Construction, Contraction and Expansion Joints in Concrete Water Retaining Structures. Additional guidance on joint design and installation is given in BS 5337 and a reference to the requirements for PVC waterstops is made in the Civil Engineering Specification for the Water Industry (CESWI).

PVC waterstops are generally extruded sections which are wholly or partially embedded in the concrete during construction so as to span across the joint and provide a permanent watertight seal during the whole range of repeated joint movement. Great care is required both at the joint design and waterstop installation stages to ensure the effectiveness of the structure to retain water. Mistakes may be very difficult and expensive to rectify at a later stage.

Attention is drawn to typical design and installation requirements including considerations for jointing, fixing, the placing and compaction of concrete around the waterstop and avoidance of site abuse.

This guide relates to PVC waterstops complying with the requirements of IGN No. 4-31-02 which states that it is the policy of the Water Industry to purchase products produced to an approved Third Party Quality Assurance Certification Scheme.

It has been assumed in the drafting of this guide that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose guidance it has been prepared.

This guide identifies substances and/or procedures that may be injurious to health if adequate precautions are not taken in their use and it does not absolve the user from legal obligations relating to health and safety at any stage. Similarily, it does not claim to include all the necessary provisions of a contract.

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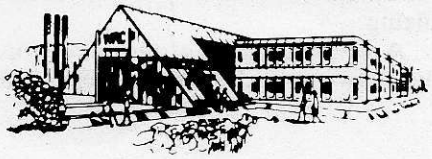


1. TYPICAL JOINTS FOR WATER RETAINING STRUCTURES

Figures 1-10 illustrate a variety of joints and applications in which internal or external types of PVC waterstops may be used. Note that the construction joint shown (figure 9) does not use a waterstop.

2. DESIGN CONSIDERATIONS

2.1 General

Water retaining structures should be designed to the Code of Practice for the structural use of concrete for retaining aqueous liquids BS 5337: 1976. [Editorial note: this Code of Practice is currently under review.] The critical nature of this form of construction necessitates that special attention should be paid to the following points.

Waterstops are required in all contraction and expansion joints, to accommodate repeated movement of the joint without loss of watertightness. Waterstops are not generally required in construction joints provided that there is complete continuity of the concrete and steel reinforcement at the joint. Attention is drawn to appropriate guidance in clause 14 of BS 5337. If complete continuity cannot be obtained, the construction joint should be treated as a contraction joint.

The waterstop selected should be of suitable width and profile to ensure that the waterpath through the concrete is sufficiently long to prevent leakage. It is recommended that the width of external waterstops for water retaining structures should not generally be less than 240 mm. For internal waterstops, the distance of the waterstop from the nearest exposed concrete face should not be less than half the width of the waterstop. This limits the width of internal waterstop that may be used. Full concrete cover to all reinforcement should be maintained.

It is common practice to specify a sealant at all joints. This serves to assist in making the joint watertight and also to exclude grit and debris which may prevent the joint closing. The integrity of different joint sealants used under various wet conditions is currently under investigation by WRc. The performance relationship of the total water sealing system should be considered, including the waterstop, sealant and joint filler where used. The total movement available at a joint is restricted by the component of the joint with the lowest movement accommodation factor. Further guidance is given in BS 5337, BS 6213, DD 69 and DD 121.

The design of the structure should provide for the continuity of the waterstop system, particularly between floor and wall systems. The waterstop manufacturer should, when possible, be consulted at the design stage to avoid complicated or unnecessary junctions.

Prefabricated junction pieces are usually available from the waterstop manufacturer to reduce the number of joints to be made during installation. Site jointing should be restricted to butt joints between the same sections. However, over-prefabrication of the waterstop system should be avoided as this may cause problems for the contractor in trying to stretch or distort the waterstop to suit the formwork or steel fixing.

A detailed layout of the waterstop system should be drawn to include the details of all standard and specialised junction pieces and should identify the concreting pours. Good preplanning should ensure that the essential junction pieces are cast in during construction to match the next run of waterstop.

2.2 Floor joints

Waterstops in floor joints are usually of the external type. Most reservoir floor slabs are not designed to span, but are directly supported by the ground and blinding concrete, which give support to the external waterstop enabling it to resist the hydrostatic pressure from above.

If the use of internal waterstops is unavoidable, it is essential that the concrete underneath the waterstop is fully compacted.

2.3 Wall joints

Internally placed waterstops are generally used in wall joints of water retaining structures. The waterstops are usually placed centrally within the wall, but may be offset if required. Note should be taken of the recommendation in 2.1 for the relationship between the thickness of concrete and the width of the waterstop.

The use of a joggle in the face of the joint to transfer shear across the joint should, where possible, be avoided. There is a risk of cracking across the base of the joggle, and during construction, joggle joints are natural collection points for debris.

If required, the transition from the internally placed waterstop in the wall to the externally placed waterstop in the floor may be achieved by the use of factory prefabricated transition pieces, a typical example of which is shown in Figure 11.

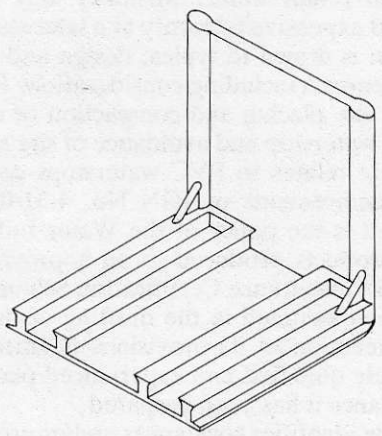


Figure 11 – Example of factory prefabricated transition piece

2.4 Roof joints

Typical roof joints are shown in Figures 8-10 including a roof/wall sliding joint. As with floor joints, external waterstops are usually used rather than internally placed waterstops.

The roof will generally be subjected to greater thermal movement than the floor, both during the construction stage when it is exposed and when the completed structure is in service, especially if the roof is not covered by backfilling. Attention should be given to the integrity of the total sealing system of joint sealant and waterstop and its ability to accommodate the joint movement.

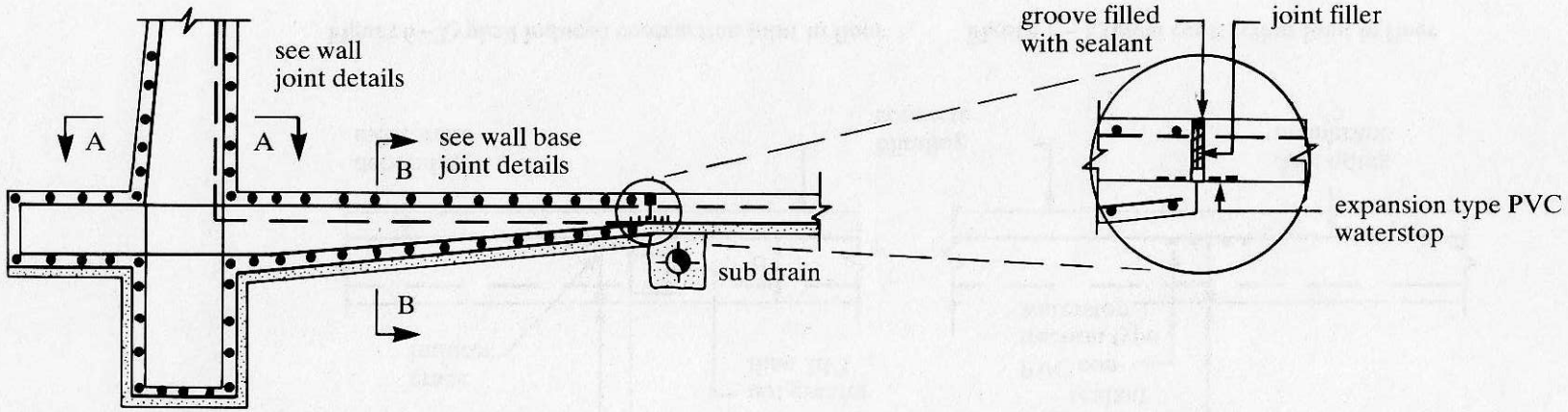
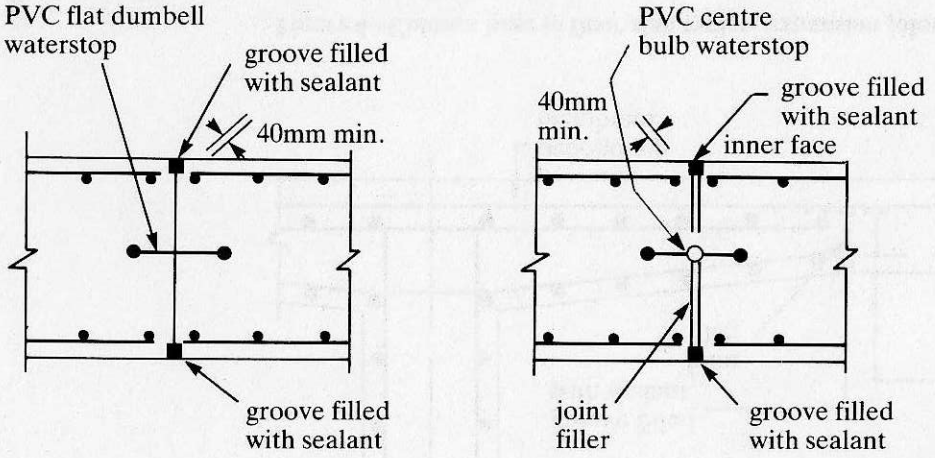
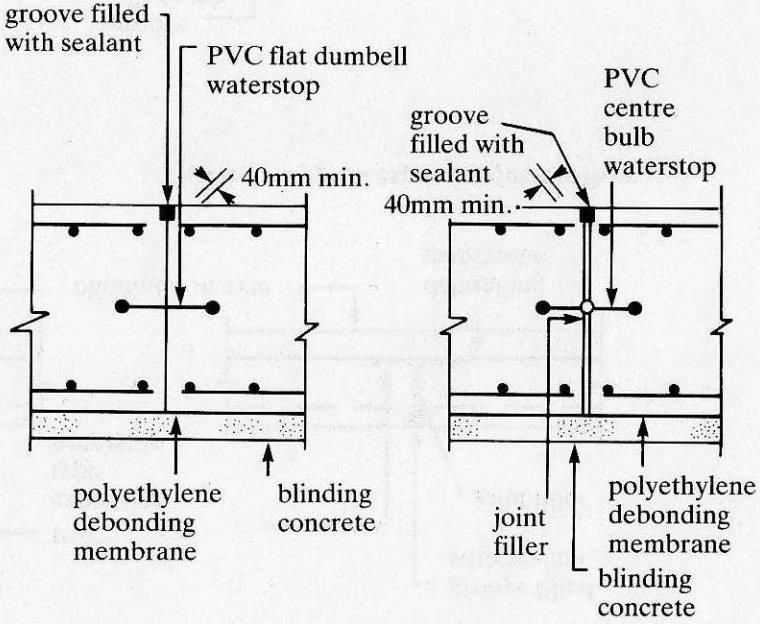


Figure 1 – Typical section through wall and base



(a) contraction **(b) expansion**

Figure 2 – Typical wall joint details section A-A



(a) contraction **(b) expansion**

Figure 3 – Typical wall base joint details section B-B

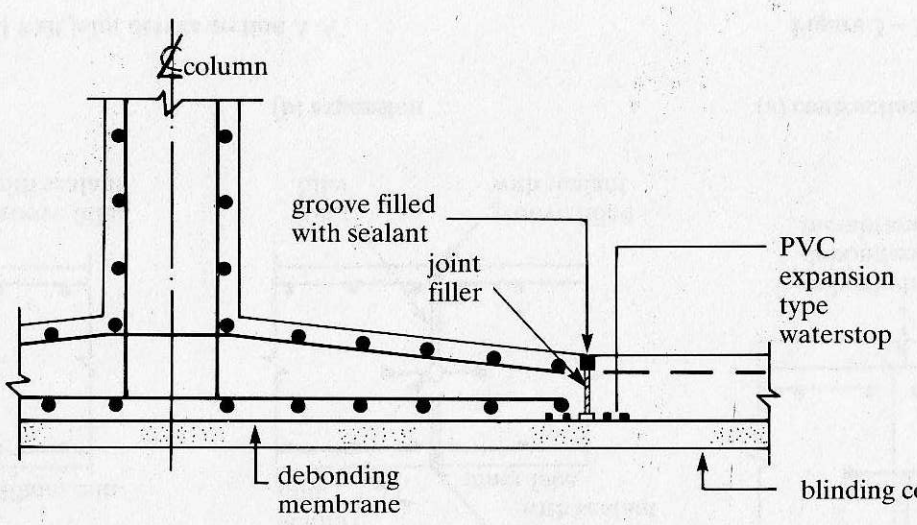


Figure 4 – Column base to floor slab typical expansion joint

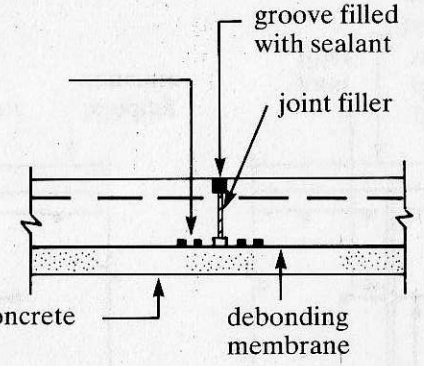


Figure 5 – Typical expansion joint in floor

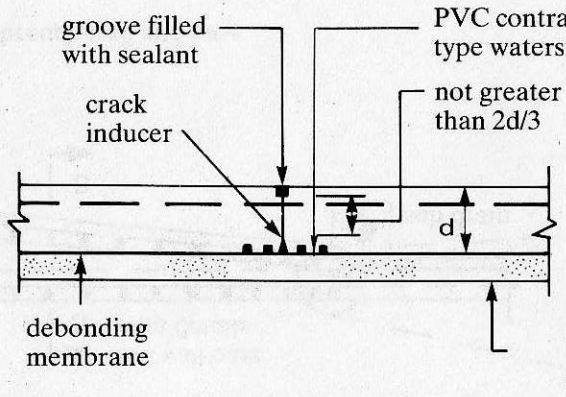


Figure 6 – Typical induced contraction joint in floor

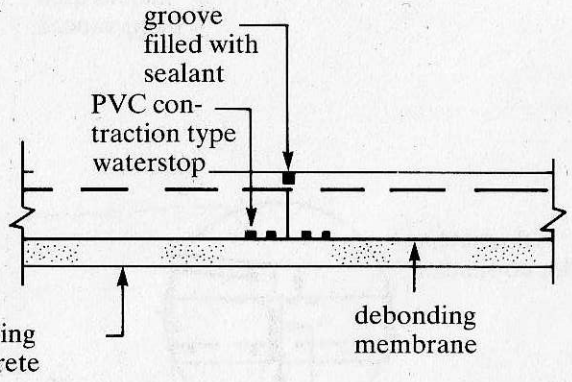


Figure 7 – Typical contraction joint in floor

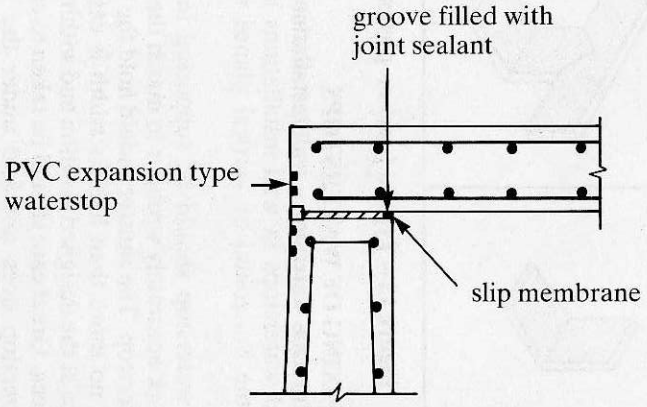


Figure 8 – Typical roof to wall sliding joint

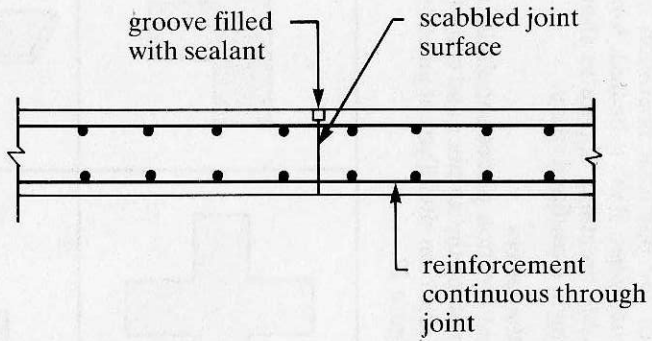


Figure 9 – Typical construction joint in roof

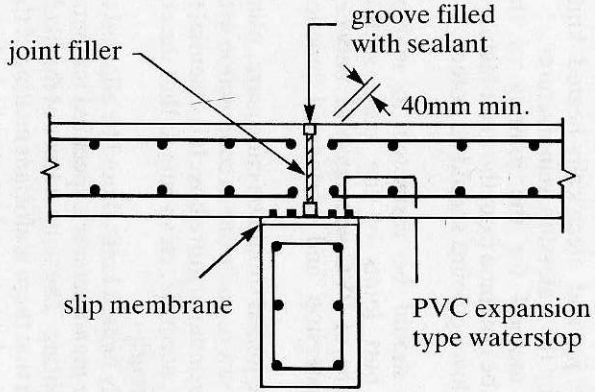


Figure 10 – Typical intermediate expansion joint in roof or roof to division wall sliding joint

3. PERFORMANCE REQUIREMENTS

PVC waterstops should comply with the performance requirements of Information and Guidance Note No. 4-31-02, Specification for Plasticised PVC Waterstops for use in Construction, Contraction and Expansion Joints in Concrete Water Retaining Structures, published by WRc and prepared by a Liaison Group under the direction of the Water Authorities Association Sewers and Water Mains Committee.

4. OPERATOR TRAINING

To achieve the level of quality necessary for a satisfactory watertight structure, adequate training of operatives, site supervision and inspection are advised.

The waterstop manufacturer should demonstrate the site jointing techniques to all persons who will be involved in site jointing. Only well-trained staff should be employed to make joints.

5. SITE JOINTING OR WELDING

5.1 Detailed method

The joints should be made by heat fusion or welding using a portable jig and electrically-heated knife usually supplied by the waterstop manufacturer.

The detailed method for the jointing of the waterstop should be obtained from the manufacturer. However, the following points should be noted:

- Site jointing should be restricted to making straight run butt joints of the same section between lengths of PVC waterstop or between lengths of waterstop and performed junction pieces.
- The ends to be joined should be cut square, using a sharp knife, saw or guillotine in conjunction with a metal square or metal mitre box. It is essential to make straight, accurate, clean cuts so that the cut ends mate properly.
- The electrically heated knife should be allowed to stabilise at the manufacturer's specified temperature before jointing. The temperature of the blade should be such that there is efficient melting of the PVC without charring when applied for a specified period to the mating surfaces (as below).
- The ends to be joined should be lined up in precise opposition in the jig. When the heated blade is inserted between the two ends, the PVC is melted on contact. The blade is removed after a specified period of contact and the two ends of the waterstop immediately pressed together, accurately aligned in the jig, and held in position for a specified period until the PVC has solidified.
- Until the joint has fully cooled it should be treated with great care since rough handling or stretching may weaken the joint leading to subsequent failure.
- It is important that the waterstop profile in the area of the splice be as close as possible to the original in order to maintain the length of the fluid path around the waterstop.
- All joints should be inspected for misalignment, bubbles, inadequate bond, porosity, cracks, offsets and charring. If necessary, the joint should be remade to the standard acceptable to the site engineer. In cases of dispute attention is drawn to the joint strength requirements for prefabricated systems given in IGN No. 4-31-02.

5.2 Health and safety

The manufacturer's Health and Safety Guide should be consulted and any recommendations implemented prior to site jointing.

In view of the potential liberation of hydrogen chloride fumes when PVC is heated, forced ventilation or suitable breathing apparatus should be used when welding in a confined space.

5.3 Junction pieces

Prefabricated junction pieces should be used where possible to reduce the number and complexity of the joints to be made on site. Typical junction pieces are shown in Figure 12.

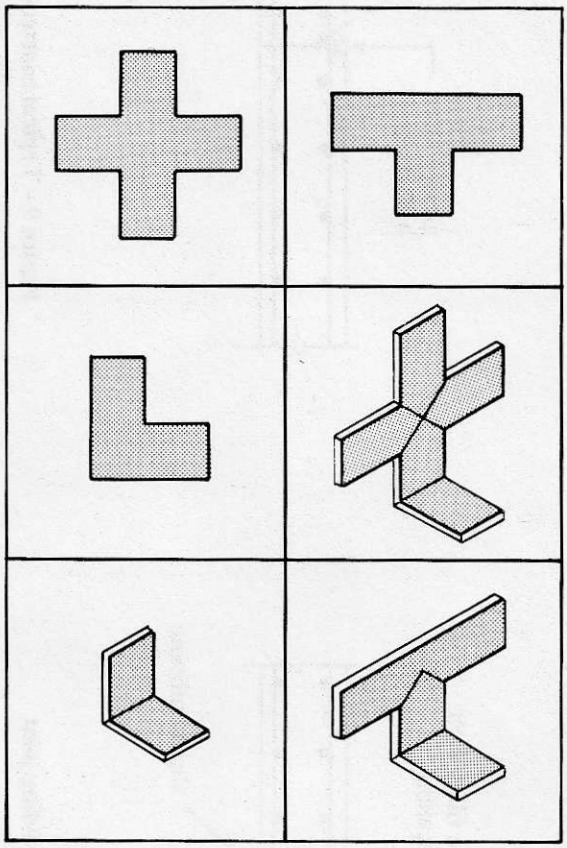


Figure 12 – Typical junction pieces

6. FIXING OF WATERSTOPS

6.1 Internal waterstop – wall installations

Internal waterstops in wall installations may lie in either the horizontal or vertical planes within the wall.

The waterstop should be supported in split-end formwork accurately wrought to match the profile of the waterstop. The shutter should hold the waterstop so that no more than half its width is cast into the concrete at the designed position and within specified tolerances. Great care should be taken to ensure that the waterstop does not fold under the weight of placed concrete. To eliminate foldover particularly in horizontal installations, the waterstop should be wired to reinforcing steel in accordance with manufacturer's instructions. The wire ties should not puncture the waterstop anywhere other than at the positions provided or recommended by the manufacturer.

6.2 Internal waterstop – floor/roof installations

Internal waterstops are not recommended for use in floor or roof installations due to compaction difficulties for the concrete. However, if the use of internal waterstops is unavoidable, the following should be observed.

The waterstop should be supported in formwork as described in 6.1. The waterstop should not be wired so that it may be lifted for proper concrete placement and compaction. The waterstop should not fold over under the weight of the concrete.

6.3 External waterstop – floor/roof installations

The waterstop should be laid on the blinding concrete, or shuttering, whichever is appropriate, along the intended line of the joint before the bottom steel reinforcement is placed. This sets the pattern of the bays prior to concreting and allows the site welds and the overall quality of the installation to be checked. The stop end boards should then be firmly bedded on to the waterstop.

7. CONCRETE PLACEMENT AND COMPACTION

7.1 General

A waterstop is only as effective as the concrete into which it is cast. Concrete does not bond to PVC and the "hold" is provided by well-compacted concrete all around the waterstop. Poor compaction or placement of the concrete may lead to honeycombing with resultant water percolation around the waterstop.

The following points should be noted prior to concrete placement.

- Stop end shutters should be carefully blown out to remove any debris.
- Externally placed waterstops should be thoroughly cleaned out between the sealing flanges.
- Shutters should be checked for firmness against the waterstop to avoid grout seepage.
- Waterstop ties should be checked to see that they are firmly fixed.
- A final check should be made that all waterstops are correctly placed and that all junctions are correctly installed for adjacent pours.

7.2 Internal waterstop – walls

(a) **Vertical installation**
Special care should be taken to avoid the waterstop folding when the the concrete is tipped to one side of the waterstop. Where tying wires are used, the wire should not prevent the vibrator being placed tight to the waterstop or the stop end shutter with resultant poorly-compacted concrete in that zone.

(b) **Horizontal installation**
As with the vertical installation, folding of the waterstop should be avoided. With heavy concrete pours, the flow should be directed towards the shutter. Unless properly secured, the waterstop may fold over creating a cavity under the waterstop. The concrete should be carefully placed around the waterstop to avoid the securing wire eyelets tearing.

The concrete should be gradually poured to cover the whole waterstop, then thoroughly vibrated ensuring that the vibrator does not foul the tying wires preventing it reaching the bottom of the shutter.

7.3 Internal waterstop – floor/roof

The edge of the waterstop should be lifted and the concrete beneath the waterstop placed firmly against the stop end shutter. This should then be vibrated to give good compaction with no honeycombing. After this initial stage, the waterstop should be lowered and further concrete placed around the waterstop and vibrated. Care should be taken not to push the waterstop down when vibrating. Attention should be given to reverse any natural curling tendency of the waterstop.

7.4 External waterstop – floor/roof

The concrete should be poured against the stop end shutter and well vibrated to ensure compaction above the waterstop.

8. AVOIDANCE OF DAMAGE TO THE WATERSTOP

8.1 Storage

PVC waterstops meeting the requirements of IGN No. 4-31-02 may be stored outside without protection in the UK for the storage life claimed by the manufacturer. However, the waterstop should be stored in an area where it will not be liable to damage, for example, by site traffic, plant or other site materials.

The waterstop should be well supported so that it is not distorted or takes a permanent set during storage. The manufacturer's recommendations for the method of support and stacking heights should be followed.

8.2 Installation

When fixing to formwork the contractor should only use the recommended fixing procedures and not puncture, cut or tear the waterstop to suit reinforcement or generally secure the waterstop in an unauthorised manner.

Jointing should only be carried out in the manufacturer's recommended manner. Nailing or overlapping of waterstops should not be permitted.

Care should be taken to avoid mechanical damage to the waterstop by site traffic, plant or other site materials. The waterstop is particularly vulnerable when one half is bedded in concrete and the other half is exposed. Satisfactory repairs at this stage may be very difficult and costly, and in some cases may not be possible.

9. REFERENCES

WAA SWMC Information and Guidance Note No. 4-31-02 Specification for Plasticised PVC Waterstops.

BS 5337	Code of practice for the structural use of concrete for retaining aqueous liquids.
BS 6213	Guide to the selection of construction sealants.
CESWI	Civil Engineering Specification for the Water Industry.
DD 69	Method of classifying the movement capability of joint sealants.
DD 121	Classification system for sealants for building and construction.