Repairs to joints

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Poorly detailed joints often contribute significantly to the distress of a structure. The example of one such simple structure is illustrated in this article. In this particular case, the expansion of the structure had accumulated over three sets of expansion joints and the displacement was so much that the top position of the masonry column on which a beam was resting had sheared off in the direction of expansion. Some of the important aspects to be considered in the repair of joints are described in the article.

Joints are an inevitable part of any structure. The size of the structure, type of building material, method of construction etc. determine the number and types of joints on a structure. They can be categorised broadly as expansion joints, joints between dissimilar materials, and joints between precast elements and paving joints (on concrete roads).

It has been the author's experience that many of the structures that come up for repairs have poorly detailed joints which themselves contribute to distress in the structure to some extent. Example of one such simple structure is illustrated here. The building is a long structure with masonry walls and columns, *Fig* 1. It consists of two long walls of about 300 m with masonry columns at every 3.5 m. Reinforced concrete (RC) beams rest on these masonry columns (spanning between two walls). Slab spans between beams. This simple structure has many expansion joints at about 20 m on centres (o.c). Due to problem of leakage through joints, number of attempts were made including covering the joint with a RC hood, *Fig* 2. Such arrangements have led to blockage of the expansion joint.

Owing to this, expansion of the structure accumulated over three sets of expansion joints and the displacement was so much that the top position of masonry column on which the beam rested had sheared off in the direction of expansion, *Fig* 3.

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The suggested solution to the problem is shown in *Fig* 4.

Intention of a joint is to allow possible movement at the control section, which avoids distress elsewhere. The joint sealant in turn should be capable of absorbing the expansion envisaged (with an adequate safety margin). This aspect of adequate margin is often overlooked while detailing. The codal provisions are adhered to as far as spacing of joints, expansion in particular, is concerned. However sizing of joints is done without any regard to the movement absorbing capacity of the sealant. This results in improper functioning of the joint. Thus spacing of joints, sizing and detailing of joints, type of sealant chosen --- all play an important part in joint treatment.

A comprehensive classification of joint sealing materials, their expansion/ contraction capabilities and properties is given in *Tables* 1 and 2.

The movement capability is expressed as a +/- percent value. The plus value indicates the amount of movement the sealant can take in extension in a typical joint, and minus value indicates the amount of movement the sealant can take

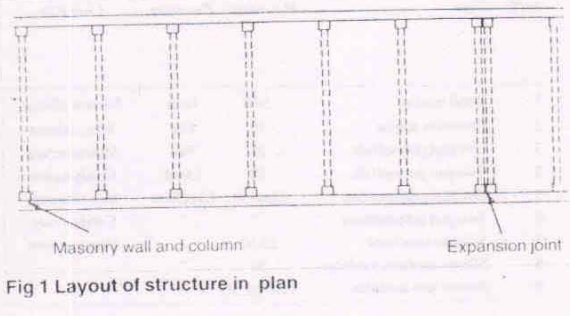

Fig 1 Layout of structure in plan

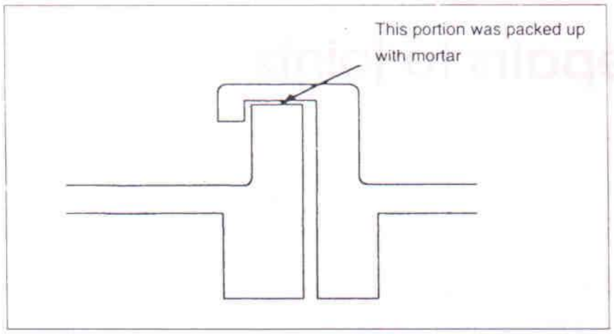

Fig 2 Detail of an attempted RC hood

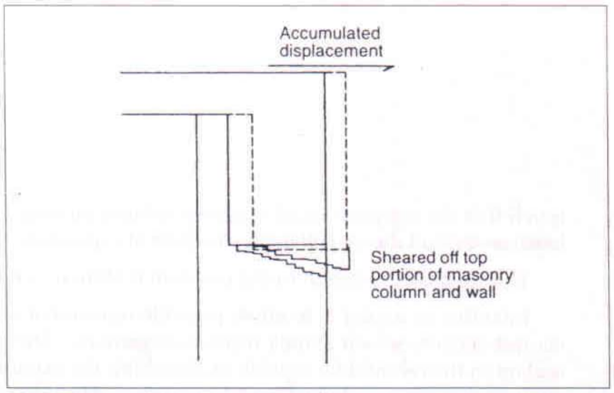

Fig 3 Damage at masonry column top

in compression in the same joint. In both the cases the comparison is with the original dimension of the sealant at the time of the sealant installation.

Butt and lap joints

Butt joints are used in external panel joints, expansion joints and masonry control joints. They cause compressive and tensile stresses in the joint sealant, and the stresses induced are high. In comparison, lap joints are used for external panel to mullion joints, external panel to sill joints etc. While a sealant can take 25 percent joint movement in a butt joint, the same

Table 1 : Classification of sealants

Sr.No.	*Type*	*Movement*	*Recovery*	*Cure type*	*Specifications Standards*	
					Federal	ASTM
1.	Butyl mastics	5-10	Poor	Solvent release	-	-
2.	Emulsion acrylic	10	Fair	Water release	-	C-834
3.	One part polysulfide	25	Fair	Moisture cure	230 C	C-920
4.	Two part polysulfide	25	Good	Catalyst cure	227 E	C-920
5.	One part polyurethane	Upto 50	Excellent	Moisture cure	230 C	"
6.	Two part polyurethane	"	"	Catalyst cure	227 E	"
7.	Silicone structural	25-50	"	Moisture cure	230 C	"
8.	Silicon medium modulus	50	"	"	230 C	"
9.	Silicon low modulus	+100 to -50	"	"	230 C	"

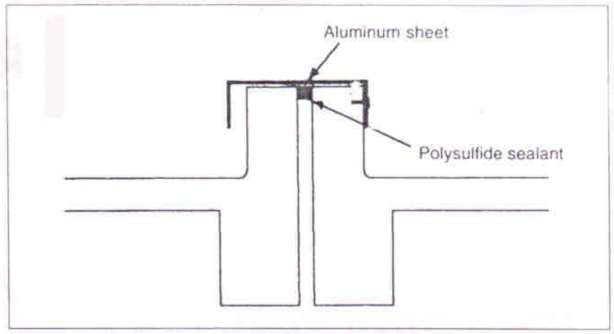

Fig 4 Proposed scheme for joint

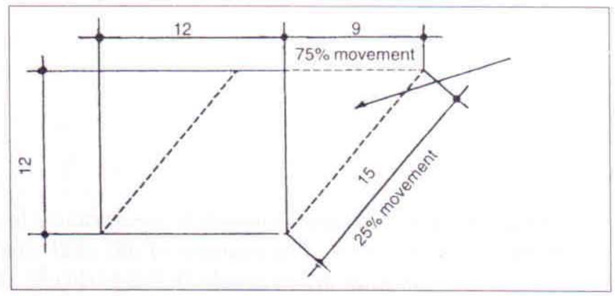

Fig 5 Movements in lap shear

sealant in a lap joint takes only extension movement and the sealant surface can be displaced by as much as 75 percent of sealant thickness in either direction. *Fig* 5 gives more details on this aspect.

Computation of theoretical value of joint movement based on temperature changes is quite straight forward. However, difficulty arises in assessing this temperature change. *Fig* 6 gives the possible temperature extremes. Actual temperature variation would be anywhere below these extremes. It is the judgment of a detailer to decide the value to be chosen. The actual time period of sealing would help in deciding the actual possible variation. Thus for a concrete structure with coefficient of thermal expansion of the order of $1 \times 10^{-5}/°C$, the above extremes would give rise to an expansion or contraction of about 0.6 mm/m. In case the application temperature is moderate, then actual expansion/contraction could be about 0.3 to 0.4 mm/m length of the building or structure.

For example, if the structure is 20 m long, then movement is 6-8 mm. With 25 percent movement capability of sealant, the joint width should be of the order of 25-30 mm.

Construction tolerances

The theoretical joint width as determined above would not necessarily be found on site. This is due to misalignment in placing precast panels. As a result, the actual joint width available may vary by the amount of tolerance of erection. One has to account for such tolerances and add it to proposed

Table 2 : Performance capabilities of sealants

Sr.no	Type	Joint limits	Expected life, years	Resistance to		
				Ultra violet rays	Ozone	Heat ageing
1.	Butyl Mastic	8x8 mm	5-10	Fair	Fair	Good
2.	Emulsion Acrylic	12x12 mm	10	Poor	Poor	Harders
3.	One part polysulfide	20x12 mm	10	Crazes	Crazes	Crazes
4.	Two part polysulfide	20x12 mm	20	"	"	Toughens
5.	One part polyurethene	30x8 mm	20	Good	Good	Good
6.	Two part polyurethane	50x12 mm	20-25	V.Good	V. Good	V. Good
7.	Silicon structural	20x20 mm	30	"	"	"
8.	Silicon medium modulus	20x20 mm	30	"	"	"
9.	Silicon low modulus	20x20 mm	30	"	"	"

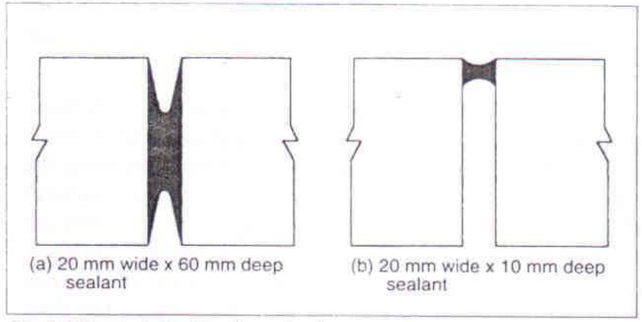

Fig 8 Effect of depth of sealant

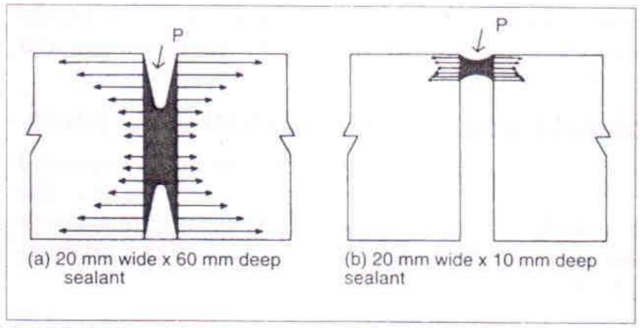

Fig 9 Substrate stress in deep and shallow joints

joint width. A wider joint would only consume more sealant but a narrow joint would affect performance considerably.

For joints which are smaller than the required width, a joint sealing detail as shown in *Fig* 7 can be adopted. The joint functions by shear movement of the silicone sealant. Total displacement possible with 25 percent grade silicone sealant would be 12 mm.

Joint sizing

Joint sealing materials play an important part in overall performance of a building and hence they should be carefully selected. Elastic sealants capable of + 25 percent movement are primarily used for exterior panel joint sealing, window sealing and expansion joints. They return to original shape after removal of an imposed force. Major rules for sizing joints are given below.

1. Minimum joint size should be 6x6 mm.
2. For 6 mm to 10 mm width, depth should be equal to width.
3. From 10 mm to 25 mm width, depth should be half ofwidth.

Why shallow joint ?

Fig 8 shows two joints with a width of 20 mm but with different depths. Both are extended by 25 percent. Sealant does not change in volume during extension. Thus deeper sealant has to neck down further when both joints are extended the same

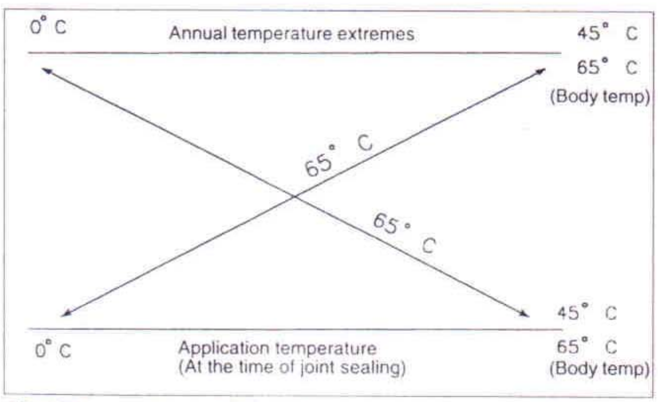

Fig 6 Temperature variation in joint

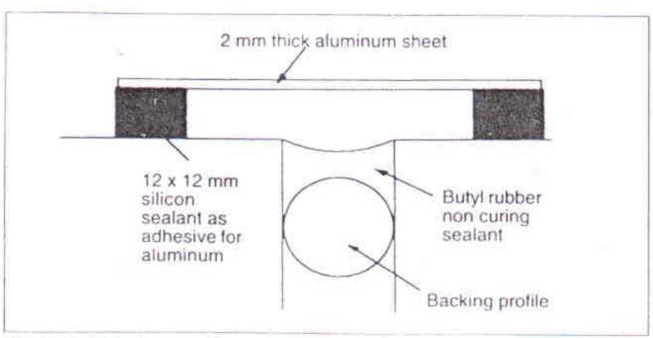

Fig 7 Details for sealing very narrow joint

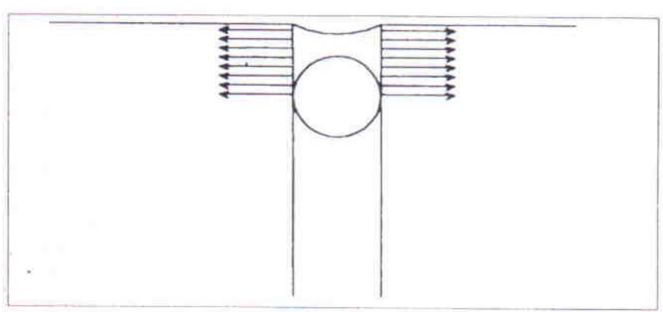

Fig 10 Uniformed stress on joint faces of tooled joint with backing profile

distance. In this case top and bottom surface of the sealant has extended a great deal more than the corresponding surface in the shallow seal.

When a bead of an elastic sealant material is deformed, the top and bottom surfaces of the sealant neck down into a parabolic shape. Strain can be compared by comparing the lengths of the parabolic curves. Since top and bottom surfaces undergo maximum strain, the stresses at these joints are maximum. *Fig* 9 shows stress distribution at interface. Direction of maximum stress, *P* has more vertical component in deep seal compared to shallow seal. As a result, the deep seal has a tendency to peel off at interface.

If the joint is provided with a curved backing, non-stick profile and is tooled from top to give a concave shape, the stresses at interface during expansion are uniform and desirable, *Fig* 10.

Special treatment of industrial floor joints

Joints in the floor panels in industries, particularly subjected to vehicular traffic tend to get damaged very quickly. The type of sealants available in the market need to be modified in order to make them suitable for use in this particular application.

The edges of existing joints need to be chipped off and repaired with polymer-modified mortars / epoxy mortars. The movement expected on panel joints are much smaller compared to expansion joints. The main reason is that the panels are not exposed directly to sun or heat. As a result, the requirement of the sealing material is a moderate movement capacity of up to 10 percent and more toughness against wear and tear. This can be achieved by formulating a polysulfide sealant along with a toughener based on epoxy resin. The combination made with 100 parts polysulfide to 40-50 parts resin toughener has given satisfactory results. The basic epoxy toughener also should exhibit elasticity.

Conclusion

Sealing of joints may appear to be trivial in comparison to other activities of construction. In fact it demands a lot of thought in design, detailing, and specification drafting. Execution of joint sealing should also be done with great care. This applies to new joints as well as repairing of old non-functional joints. Any shortfalls in above would lead not only to bad joints but also to structural distress.

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