TECHNICAL INFORMATION ON BUILDING MATERIALS

TIBM - 55

FOR USE IN THE DESIGN OF LOW-COST HOUSING

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WATER-TIGHTNESS OF EXPANSION JOINT MATERIALS IN CONCRETE ROOF CONSTRUCTION

The information contained in this paper was obtained from the results of tests conducted by D. W. Kessler, on 36 proprietary joint fillers, representative of 13 types of plastic and metal expansion joint materials, as applied to the problems of concrete roof and parapet construction. The tests included accelerated weathering; low temperature; high temperature; cycles of low temperature, soaking in water, and high temperature; and outdoor exposure. Special forms of sheet metal joints were tested for resistance to cycles of compression and tension only; that is, fatigue.

The plastic materials investigated, included: rubber latex; premolded types (sponge rubber, etc.); bitumens; plastic bitumens; rubber in flux; and oil mastics.

The rubber latex type is a recent development, still in the experimental stage. Each sample consisted of three separate parcels: (1) a white paste of creamy consistency, (2) a fine powder resembling an aluminous cement, (3) a mixture of parcel No. 2 with granulated cork. Numbers 1 and 2 were mixed for coating the surface to be joined. After this coating had hardened, a mixture of 1 and 3 was used to fill the joint. The material hardens rather slowly, especially on the interior, and considerable shrinkage occurs. The hardened mass has the properties of rubber and bonds well with concrete.

Another special type is the Grund joint, intended for a specific purpose. It consists of a cement-asbestos board grooved on each face to receive a bead of caulking material. This expansion gasket is intended for use in vertical joints of copings, cornices, belt courses, etc. The gasket is made the same shape as the vertical cross section of the course of stone in which it is to be used. The grooves parallel the edges, forming a closed figure somewhat smaller than the cross section of the masonry unit joint. The bead of caulking material is placed in the grooves with a caulking gun just before each stone is set. This type of joint filler can be used only during construction of the building. The advantage is that having the joint thoroughly sealed and the caulking deep in the joint, the plastic is not forced to the surface by high temperatures. This should prove more durable than caulking compound applied in the usual way.

An extruded rubber type is made about 1/4 inch wider than the joint and forced in after the concrete has hardened. The elasticity of the rubber is depended upon to maintain a firm contact with the materials joined.

The sheet metal joints examined were evidently developed for concrete road construction, but were subjected to such tests as are of interest in connection with roof slab use.

METHODS OF TESTING

(a) Weatherometer Tests: A determination of the resistance of materials to the effects of alternating water spray, and light and heat from a carbon arc lamp. This is an accelerated weathering test. Results were determined by appearance and changes in plasticity (penetrometer test).

(b) Concrete Joint Expansion: Two concrete blocks, controlled in lateral motion by bolts and nuts, were constructed. A small reservoir was made in the tops of the blocks to permit the joints to be tested for water-tightness. Three specimens of each sample were used in the following tests: exposure on the roof; cold storage; hot storage; and temperature and moisture cycle.

(c) Compressive Tests: The specimens of premolded joint materials were tested in compression by means of a 100,000 pound mechanical testing machine, operated at a speed of 0.05-inch per minute. Fifty percent deformations of the thickness of the sample were made and the rate of recovery studied after compression.

(d) Absorption Tests: The specimens were oven-dried for 24 hours at a temperature of 50°C. After removal from the oven the samples were cooled and weighed, then immersed in water. After 24 hours in the water, they were removed, surface-dried with a damp towel and immediately weighed. The gain in weight times 100, divided by the dry weight, gave the percentage of absorption.

(e) Fatigue Tests: The only materials subjected to the fatigue test, which consisted of repeating the cycle of contraction and expansion of the joint, were those of the metallic type.

RESULTS OF TESTS

RUBBER LATEX TYPE

Weatherometer Test: The two samples started to blister and crack during the first 24 hours of exposure. After 6 weeks one sample was so badly shrunken and cracked that the test was discontinued. Another sample was removed in a similar condition after 9 weeks, but was still somewhat pliable at the bottom (1-inch below the surface exposed to light).

Outdoor Exposure: Samples gave satisfactory extension values after 12 weeks, one sample giving a maximum value of 3/8-inch. Only one bond failure occurred in the 6 tests made.

Low Temperature: One sample cracked within the joint filler, causing a failure at 0.06-inch extension. Samples showed good bond properties.

High Temperature: Results were consistent, giving extension of 1/8-inch before failure.

Cycles of Heat, Cold and Moisture: Samples gave extension values of over 0.2-inch. Failure was usually in the joint material itself, but one failure occurred in the bond.

PREMOLDED TYPE

Weatherometer Test: Out of 12 samples, the only materials of this class which showed any serious effects from exposure were two sponge rubber samples. One shrank, warped, and became very hard. The other showed a similar effect, but to a much less degree. Rubber-bound cork and extruded rubber also suffered some hardening effects. The premolded asphalts showed surface hardening, but this was not considered serious. Cork samples were not visibly affected, although there was an appreciable weight loss.

Outdoor Exposure: At the end of the exposure period, 4 of these types leaked without extension, and the extruded rubber was the only one that gave an extension value as high as 0.2-inch. Tests at the end of 6 weeks without extension showed that most of the specimens were water-tight. One asphalt-type and one fiber-type joint split in the extension tests.

Low Temperature: One fiber-type, one asphalt-type and the extruded rubber sample gave fairly satisfactory performance in this test. Failures were mostly in the bond, but one asphalt sample and two fiber samples split during the extension of the joints.

High Temperature: Extensions in the fiber, asphalt and extruded rubber samples gave values of more than 0.1-inch before failure. The results of this type seem to depend largely on the strength of the bond with the concrete.

Cycles of Heat, Cold and Moisture: Two samples gave extension values of over 1/8-inch. The others ranged from zero to 0.06-inch. Practically all of the failures were in the bond.

BITUMENS

Weatherometer Test: Six samples of bituminous materials for hot application were subjected to this test. None was materially injured, but all formed hard skins on the exposed surface, which prevented a reading on the penetrometer. As a class, these samples were affected less than other types in this test.

Outdoor Exposure: All samples were found to be water-tight at the end of 6 weeks. At the end of 12 weeks all were tested by extension to failure, the highest average value for one sample being 0.13-inch and the lowest 0.03-inch.

Low Temperature: This test produced a rather hard and brittle condition. The highest extension before failure was 0.08-inch. Two failed in the bond and three cracked in the joint filler.

High Temperature: All samples were very soft. With one exception, extensions of 3/8-inch without failure were obtained.

Cycles of Heat, Cold and Moisture: Three samples were difficult to keep in the joints. Two others shrank excessively and leaked without extension. Five samples gave high extension values at the end of the test.

PLASTIC BITUMENS

Weatherometer Test: Seven samples of cut-back bitumens with fillers (intended for cold application) were included in this test. All except one sample showed a very marked change in plasticity and this one developed a hard film on the exposed surface. After a short time, six of the samples developed brittleness.

Outdoor Exposure: Test results were variable, two showed leaks without extension and only one showed a high extension value. Two failed by shrinkage and cracking. Failures indicated that the materials were generally lacking in adhesive properties.

Low Temperature: All of these materials gave fairly satisfactory performances in this test. Four gave extension values of more than 3/8-inch. Two failed in bond under comparatively low temperatures.

High Temperature: Difficulties were experienced in keeping some of these materials in the joints at high temperature. One became rather hard and another suffered from loss of oil. Two showed high extension values, while the other four ranged from zero to about 1/8-inch.

Cycles of Heat, Cold and Moisture: Results on four of the seven samples were rather unsatisfactory. Two of these leaked without extension of the joint. Only one sample gave consistently high extension values.

RUBBER IN FLUX

Weatherometer Test: One sample was tested. After 6 months exposure a thin crust was formed on the surface, but otherwise there was no apparent change. The weight loss was very small.

Outdoor Exposure: The thin consistency of this material caused excessive losses around the gaskets (used to hold the material in the joint). The specimens maintained water-tight joints to the end of the test and gave extension values of 3/8-inch.

Low Temperature: This material was slightly stiffer at the low temperatures, but did not fail at 3/8-inch extension.

High Temperature: The material was difficult to confine at high temperature, but gave a high extension value.

Cycles of Heat, Cold and Moisture: Showed uniformly high extension values, with no failures at 3/8-inch.

OIL MASTICS

Weatherometer Test: Four materials were tested; two were rather soft, one somewhat stiffer (a gun grade), and the fourth quite stiff (a knife grade). This latter became hard on the surface during the first 15 days. Even after 3 months exposure, however, with the surface of some of the samples becoming hard and brittle, they remained plastic below the hard film.

Outdoor Exposure: The soft materials gave good performance. The gun grade showed a weak bond, while the knife grade gave fairly satisfactory extension values.

Low Temperature: Three samples were satisfactory, while one failed at a low extension.

High Temperature: The gun grade sample gave a low extension value. The others ranged from 0.09 to 0.38-inch.

Cycles of Heat, Cold and Moisture: Of the two soft grades, all samples gave high extension values except one, which leaked without extension because of excessive shrinkage. The knife grade sample failed in bond under an extension of slightly more than 1/8-inch, while the stiff gun grade material gave less satisfactory results.

FATIGUE TESTS

Three samples of prefabricated sheet metal joints were submitted and tested. The joints were made by casting the samples in concrete blocks and subjecting them to cycles of contraction and expansion until the metal cracked. The results of the test on 8 samples, for joint movements from 0.25 to 0.46-inch, were as follows:

Designation	Movement	No. of cycles	Nature of failure
M_2	0.440	258	Crack started at center.
	.440	285	Failure.
M_2	.450	202	Crack started at center.
	.450	205	Failure.
M_3	.250	458	No apparent change.
	.375	+34	Cracked at center.
M_3	.375	78	Cracked at center.
M_3	.460	46	Cracked at center.
M_1	.370	327	Cracked where metal enters concrete.
	.370	478	No change, test ended.
M_1	.350	750	Cracked where metal enters concrete.
M_1	.412	234	Cracked where metal enters concrete.
	.412	484	Cracked at top of bellows.

CONCLUSIONS

1. The rubber latex expansion joint materials gave good bonding and extension values but indicated unsatisfactory durability.

2. The fiber boards impregnated with bituminous materials were variable in their behavior. Some of the experimental joints leaked without extension and a few gave extension values over 1/8-inch.

3. The premolded asphalt joints gave results similar to those of the fiber boards. The original shrinkage of the concrete in hardening is likely to break the bond. Such materials showed little elastic recovery, and the tightness of the joints at low temperatures depended upon the bonding properties. In large structural members, the shrinkage of the concrete may cause failure of the joints.

4. The sponge rubber samples gave somewhat more consistent results than the fiber and asphalt boards, but the extension values were all rather low. The durability of these materials, when exposed to light, was not very satisfactory.

5. Tests on cork joints showed extension values as high as 0.08-inch, but the results were not very consistent. Inspection of materials in service showed that water-tight joints were not obtained when concrete was poured next

to the cork. Precompressed cork fitted into the joint after the concrete hardens, may give better results. The sample of rubber bound cork gave results similar to those of the resin bound corks, except that it was affected by more exposure to light.

6. The sample of extruded rubber gave extension values from 0.11 to 0.23-inch. Protection from sunlight is recommended.

7. The bituminous materials intended for hot application gave high extension values when warm, but at cooler temperatures these values were rather low. At 12°F, the highest extension value was 0.08-inch.

8. Most samples of plastic bitumens usually gave ample extension values at both high and low temperatures, but in the weather exposure, cycle, and weatherometer tests, the performance of some were not very satisfactory. Better durability may be expected from such materials where they are protected from sunlight.

9. The sample of rubber and asphalt composition gave satisfactory extension values in all tests and was little affected by light exposures. Special precautions should be taken to prevent the material flowing from the joint.

10. The oil mastics gave somewhat more consistent results than the bituminous mastics and seemed to deteriorate less when subject to light exposure. Better durability may be expected from such materials where the concrete is treated with a suitable primer.

11. Sheet metal joints are considered the most suitable type for roof construction, but the designs used in concrete roads could be modified to give longer service in roofs.