SESSION VI, Papers 1–9

VI–1. The Larson Waterproofing System for Brick Walls: Its Performance in Newfoundland

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ABSTRACT

The Larson System, consisting of a water impermeable membrane barrier sealed in exterior masonry walls to prevent rain penetration, was used in about 20 buildings built in St. John's and other parts of Newfoundland during the 1958–65 era. Observations of many of these buildings through the years have provided an opportunity to assess the performance of the system under severe conditions of exposure to driving rain and freeze-thaw cycling. The overall performance, with respect to rain penetration, was superior to that for contemporary buildings with walls of conventional construction. The membrane prevented a serious problem in one building where deterioration of the exterior wythe would normally have resulted in rain penetration of the walls. The causes for deterioration in the exterior wythe of this building are examined.

The superior performance, under severe exposure conditions typical for this Canadian island province located off the north-east coast, was not predictable on the basis of tests done on panels containing the membrane at the National Bureau of Standards in the 1940's. An examination of weather records for St. John's for the period 1963–76 indicates that exposure conditions never approached the severe conditions imposed by the test method.

Le système Larson, consistant en une membrane imperméable scellée dans les murs extérieurs de maçonnerie pour prévenir la pénétration de la pluie, fut utilisé dans une vingtaine de bâtiments construits à St-Jean et ailleurs à Terre-Neuve entre 1958 et 1965. L'observation de beaucoup de ces bâtiments au fil des ans a permis d'évaluer le rendement du système dans des conditions rigoureuses d'exposition à la pluie battante et aux cycles de gel et de dégel. Le rendement global, en ce qui concerne la pénétration de la pluie, était supérieur à celue de bâtiments de la même époque avec des murs de construction traditionnelle. La membrane empêchait un grave problème dans l'un des bâtiments où la détérioration de la paroi extérieure aurait normalement causé la pénétration d'eau dans les murs. Les causes de la détérioration de la paroi extérieure de ce bâtiment sont examinées.

Le rendement supérieur, dans des conditions d'exposition rigoureuses typiques à cette . .île et province du Canada située au large de la côte nord-est, n'était pas prévisible, compte tenu des essais sur des panneaux contenant la membrane effectués au bureau national des normes (National Bureau of Standards) au cours des années 40. Un examen des relevés météorologiques à St-Jean pour la période de 1963 à 1976 indique que les conditions d'exposition n'ont jamais approché les conditions extrêmes imposées lors des essais.

Das Larson-System besteht aus einer wasserundurchlässigen Membransperre, die in aus Ziegeln hergestellte Aussenwände zum Schutz gegen Regendurchschlag eingebaut wird. Während der Jahre 1958–1965 wurde dieses System bei etwa zwanzig Gebäuden in St. John's und anderen Teilen Neufundlands bautechnisch angewandt. Inspektionen vieler dieser Gebäude in Laufe der Jahre machten es möglich die mit diesem System unter den dort vorherrschenden harten Witterungsbedingungen—strömender Regen und Frost-Tau-Wechsel—gesammlten Erfahrungen auszuwerten. Hinsichtlich des Regendurchschlags übertraf dieses System im Allgemeinen die Wirkungskraft der üblicherweise bei den seinerzeit errichteten Gebäuden angewendeten bautechnischen Verfahren. Die Membransperre verhinderte die Entstehung eines grösseren Schadens an einem Gebäude, bei dem der Zerfall des Aussenmauerwerks normalerweise zu einem Regendurchschlag geführt hätte. Der Zerfall des Aussenmauerwerks dieses Gebäudes wurde näher untersucht.

Die überlegene Wirkungskraft des Sperrsystems unter den harten klimatischen Bedingungen dieser kanadischen Inselprovinz war in Anbetracht der von dem National Bureau of Standards in den vierziger Jahren mit entsprechenden Prüftafeln erzielten Resultate unerwartet. Eine Durchsicht der Wetterberichte der Jahre 1963–1976 ergab, dass die natürlichen Einwirkungsbedingungen nie die seinerzeit festgelegten äusserst strengen Prüfungsbedingungen erreichten.

Il sistema "Larson" consiste nell'applicare alla faccia esterna di un muro di mattoni una membrana impermeabile allo scopo di impedire ogni penetrazione d'acqua piovana. Questo sistema e stato impiegato in circa 20 edifici construiti in St. John ed in altre parti di Terranova, dal 1958 al 1965.

I resultati delle ispezioni eseguite durante parecchi anni di sorveglianza su molti di questi edifici hanno permesso di valutare l'efficienza del sistema d'impermeabilizzazione "Larson" sotto severe conditioni d'esposizione a piogge torrenziali e di ripetuti cicli di gelo-disgelo. In linea generale, l'efficienza di questo sistema, in relazione alla penetrazione dell'acqua piovana, era superiore a quella offerta dalle opere murarie construite con sistemi convenzionali. La membrana ha infatti impedito il verificarsi, in uno degli edifici, di un problema alquanto

serio, dove il deterioramento dell'intonaco esterno avrebbe permesso il passaggio dell'acqua piovana attraverso le pareti in muratura. Le cause del deterioramento dell'intonaco esterno sono state investigate.

Sotto le severe condizioni climatiche che prevalgono in questa insulare provincia canadese situata sulla costa nord-est del continente, l'efficienza superiore del sistema Larson non poteva essere predetia dai risultati delle prove eseguite negli anni quaranta dall'Ufficio Nazionale per la Normalizzazione, sui pannelli muniti di membrane impermeabili. Un esame delle osservazioni meteorologiche raccolte in St. John, ha indicato che per tutto il periodo che va dal 1963 al 1976, le condizioni climatiche non sono mai state cosi severe come quelle imposte dal metodo di prova.

The Larson System, consisting of a water impermeable membrane barrier sealed in exterior masonry walls to prevent rain penetration, was used in about 20 buildings built in St. John's and other parts of Newfoundland during the 1958–65 era. Observations of some of these buildings through the years have provided an opportunity to assess the performance of the System under severe conditions of exposure to driving rain and freeze-thaw cycling.

THE SYSTEM

The Larson System, developed by the Brisk Waterproofing Company Inc., is described in their 1958 catalog[1] which claimed that it had been used in 1500 large buildings. The System consists of a series of asphalt felt units providing continuous protection while permitting the wall to breathe by leaving a break in the membrane at every sixth course of bricks. This is illustrated in Figure 1, which shows the membrane behind the exterior wythe of bricks, extending vertically behind five courses of stretchers, then horizontally under the header, and turned up back of the header and the brick above it. The next membrane unit is installed in like manner starting behind the stretcher immediately above the header. The pre-formed units are lapped four inches and sealed with mastic. The membrane is flashed to the outside at the base of the wall, and weepholes are provided to faciltate drainage. The membrane is carried in front of beams and columns (Figure 2), and is sealed to roof-cap flashings to ensure a water-tight connection with the roof system.

During construction the interior wythe of masonry is laid up first. When the required height is reached, the factory-formed membrane unit is installed and then the exterior brick wythe is laid up. The System thus ensures dimensionally accurate masonry—because the walls are built to "fit" the pre-formed units—contrary to normal masonry construction practice under which flashings are cut and fitted to partially completed wall sections.

The System carries a 10-year warranty which guarantees removal and replacement of masonry and other materials as required for necessary repair or replacement of the membrane.

NEWFOUNDLAND APPLICATION

The Larson System was first used in the Confederation Building built in St. John's during 1958–59. It was then used in four buildings on the new Memorial University Campus and later in a number of Vocational Schools built in various parts of the Province. It was also used in two Federal Government buildings and in a few private sector buildings. The following buildings located in St. John's are known to have the Larson System in their walls:

Confederation Building
Arts, Gymnasium, Engineering and Library Buildings at Memorial University
Newfoundland and Labrador College of Trades and Technology
Federal Department of Transport Building
Veterans' Wing of the General Hospital
Avalon Telephone Company
Hoyle Home for the Aged.

Some other University Buildings built prior to 1965 and most of the Vocational Schools built between 1960 and 1963 are reported to have used the System. The absence of rain penetration problems in the original buildings, in sharp contrast to the problems occurring in contemporary buildings in which the System was not used, explains the popularity of the System in the early 1960's. By 1965 installation costs had increased substantially and designers were opting for alternative solutions in the design of masonry buildings.

The writer visited St. John's during the initial installation in the Confederation Building; subsequent visits during the 1960's provided an opportunity to observe most of the other buildings where the System was used. All the buildings were visited again in 1977 in conjunction with an assessment of problems at the College of Trades and Technology.

CONFEDERATION BUILDING

A visit during construction in 1959 (Figure 3) revealed a wall system consisting of an interior wythe of 8-in. (203 mm) concrete blocks with an exterior wythe of 4-in. (102 mm) extruded buff clay bricks, the latter manufactured in the area and known to have a good performance record. The wall was laid up with a cement-lime mortar containing a waterproofing additive. The wythes were tied with a row of header bricks every sixth course.

The membrane, a Johns-Manville asphalt felt, was installed by trained personnel from the Brisk Company, but because of the distance from the factory, the units were cut and shaped in the on-site job shack. The size of the units varied depending on their ultimate location in the wall but were never too large to make installation cum-

bersome. It was noted that particular care was taken to seal, with a Miniwax mastic, openings around windows and doors, and punctures made by fasteners. There was good cooperation between the installers and the masons who were competent tradesmen brought into the area for the job. Most of the masonry was laid up in heated enclosures during winter weather.

After a rain storm during the visit some dampness appeared along header courses under several windows on the northeast exposure of the building. A year later some efflorescence was noted in this same area. Visits in subsequent years revealed some leakage related to (1) metal windows and (2) the mortar joint under a stone belt course near the top of the building, but there was no evidence of any leakage through the masonry walls. The same isolated areas of efflorescence, becoming more obvious, were noted during these later visits.

A more extensive examination was made in 1977, after the building had been in service for almost eighteen years. The isolated efflorescence areas under a few windows were more pronounced and there was some mortar breakdown in these areas, but there were no wall-related leakage problems and the walls had not been touched since their completion in 1959. The efflorescence problems were attributed to the absence of flashing under the window sills which enabled water to enter the wall through empty still joints from which the mortar had disappeared early on without ever being replaced. These observations were confirmed by the report of a consultant who had recently examined the building prior to planning an extension. He had not found any rain penetration of the masonry walls.

UNIVERSITY BUILDINGS

The four University Buildings were under construction in 1960 using the same wall system and the same materials with one exception—wooden windows were used because of problems with metal windows on the Confederation Building. The ever-present efflorescence staining at header course levels was noted on the partially completed walls, and remained visible during subsequent visits, but there was never any evidence of rain penetration problems.

In 1977, after seventeen years service, University authorities confirmed that there had never been any leakage problems, nor had there been any maintenance on the walls. There was isolated efflorescence on the walls of all the buildings, more noticeable on walls in which a darker colored brick had been used, but there was no efflorescence under windows. The efflorescence, which characteristically appeared on all the walls containing the Larson System, was the result of soluble salts deposited on the wall when water that had penetrated the exterior wythe was intercepted by the membrane and directed back to the exterior surface at header course levels. When the water evaporated soluble salts, that had been picked up by the water in transit, were left on the wall. Thus the appearance of efflorescence was an indication that the membrane was performing its intended function.

NEWFOUNDLAND AND LABRADOR COLLEGE OF TRADES AND TECHNOLOGY

This building (Figure 4) was under construction in 1961. The same wall system was used, with the membrane being installed by the Brisk Company, but other construction personnel had changed. The exterior wythe of the walls contained plum and buff colored dry-press bricks which were prone to efflorescence, early evidenced by a pronounced "bloom" on the darker plum brick during construction. An improved metal window was being used but there was no flashing under the concrete window sills.

During succeeding visits there were always heavy efflorescence deposits on the walls. Efflorescence appeared not only at header courses and under windows, but also covered large wall areas. It was particularly severe under windows on south and east walls, and mortar joints in some of these areas disintegrated rapidly at an early age. In later years there was evidence of isolated repointing, but the severe efflorescence and the progressive deterioration of mortar joints continued.

When, at the request of College authorities, the building was examined in 1977 the walls were badly disfigured with efflorescence (Figure 5) and there was serious deterioration of mortar joints in many areas, particularly on the east wall. The mortar on the west wall remained in reasonably good condition, but there was also a lot of efflorescence on this wall. A few instances of brick spalling were noted, but this was a minor problem compared with the mortar deterioration. The deterioration under some windows (Figure 6) was particularly serious, the result of water entering the wall via open sill joints. There was also a serious problem in the wall of a cantilevered section of the second storey resulting from deflection of the steel supporting member which opened the mortar joints to rain penetration.

The deterioration and/or absence of mortar in many wall areas would be expected to cause rain penetration but there was no evidence of leakage to the interior in any of these wall areas—the membrane had done its job. There were several isolated leakage problems. One was traced to a penthouse with cavity walls and no base flashing. Water penetrating the wall found a path into the building through the roof membrane. Another leak at a roof-line level may have been due to a break in the seal between the wall membrane and the roof flashing.

A number of factors contributed to the deterioration in the exterior wythe of this building including (1) the brick, (2) some relaxing of the supervision and procedures during construction and (3) absence of a maintenance program. The dry-press brick appears to have acted like a sponge, soaking up water during rainy weather, releasing it slowly and keeping the mortar wet and vulnerable to deterioration under the influence of freeze-thaw action.

OTHER BUILDINGS

Two Federal Buildings, the Veterans' Wing at the General Hospital and the Department of Transport Building, were built in 1961 and 1962. A local red dry-press brick was used in their exterior wythes, and the completed walls

were siliconed. As a result of observations on earlier buildings flashing was installed under the window sills. There has been some efflorescence on the walls through the years, but there have not been any wall-related leakage problems. These buildings have had the advantage of a regular maintenance program.

The Avalon Telephone Building completed in 1965 was one of the last in which the Larson System was used. In order to minimize the aesthetic effect of the characteristic efflorescence, the architect imported a very light buff extruded brick. He rationalized the extra cost of materials and installation of the membrane, on the premise that lower annual maintenance costs would reduce the total cost, over the life-span of the building, below that for contemporary buildings with lower initial cost, no membrane, and higher annual maintenance costs. In 1977 the building was still in good condition with some minor efflorescence but no indication of any repointing.

Hoyle Home is a three-storey residence, similar in appearance to, and in the same geographical location as the College of Trades and Technology. The exterior wythe is red extruded brick. The usual efflorescence, more obvious on the red walls, was noted in 1977.

COMPARISON OF LARSON SYSTEM AND TRADITIONAL CONSTRUCTION WITH REGARD TO LEAKAGE

During the 1959–1965 period a number of masonry buildings were built with similar wall systems without the Larson membrane. There were serious leakage problems in all these buildings. The Nurses' Residence and the Veterans' Wing of the General Hospital were both built at the same time with exterior wythes of local dry-press brick, their major difference being the use of the Larson System in the Veterans' Wing. There were leakage problems at the Residence even before its completion and in succeeding years there have been substantial expenditures for remedial action to minimize the problem. Meanwhile there has not been any wall-related leakage at the Veterans' Wing which has had a modest maintenance program.

ADVANTAGES AND DISADVANTAGES OF THE LARSON SYSTEM

The following factors favored the use of the Larson System:

1. The Company's guarantee of a leak-proof building for ten years.
2. Dimensional accuracy in the masonry wall—the result of building the wall to "fit" the pre-formed membrane units.
3. Inspection of the masonry during construction. The waterproofers watch the masons to make sure that workmanship is adequate and will not be the cause of failure during the guarantee period.

Unfavorable factors were:

1. The problem of efflorescence. Although aesthetically objectionable the appearance at the header courses indicates that the membrane is fulfilling its purpose of intercepting water penetrating the wall.
2. The cost of installation. The unit cost is probably least on large to medium projects where there is a good work flow with no interruptions.

Header brick deterioration and vertical cracking, reported to have been serious problems in Larson System buildings in some other areas, did not occur in the Newfoundland buildings.

NATIONAL BUREAU OF STANDARDS LEAKAGE TESTS VS. ACTUAL PERFORMANCE

Panels containing Larson Pre-formed Waterproofing Units were included in a study on the Water Permeability of Masonry Walls[2] at the National Bureau of Standards early in the 1940's. The panels contained high and low absorption bricks laid up with cement-lime mortar and "good" and "highly permeable" workmanship. During the 24-hour test period water was flooded onto the panels at the rate of 40 gal/hr (182 L/h), and the panels were subjected to an air pressure equivalent to that resulting from a 50 mph (81 kph) wind. There was water penetration to the back of some panels during the test period. In effect water penetrated the panels faster than it drained from the base, and was pushed over the top of the membrane by the air pressure. Reservations, based on these results, about the ability of the membrane to stop the severe wind-driven rains characteristic of Newfoundland, have been dispelled by the performance of the Larson System buildings.

In order to compare the National Bureau of Standards' test conditions with actual exposure conditions the annual summaries issued by the weather office at the St. John's airport for the years 1963–1976 were reviewed. During this period the maximum wind speed for 1 hour sometimes reached 40 to 50 mph (64 to 81 kph) accompanied by rain, but when it exceeded 50 mph (81 kph) the precipitation was snow. Maximum wind speeds for a 24-hour period seldom exceeded 35 mph (56 kph) when accompanied by rain. Gale force winds usually occurred during the late fall and winter and when accompanied by precipitation it was snow. The summaries indicate that there was never a sustained wind pressure accompanying rain storms which approached that applied in the National Bureau of Standards' tests.

CONCLUSIONS

1. The Larson Waterproofing System has been successful in preventing rain penetration through the masonry walls of buildings built in St. John's, Newfoundland between 1959 and 1965.
2. Contemporary buildings having similar wall systems, without the membrane, have had serious rain penetration problems.
3. Use of the System ensures dimensional accuracy and some inspection of the masonry during the construction period.
4. Efflorescence at header course levels is an inevitable result of the membrane fulfilling its intended function.

5. Deterioration of the exterior wythe of one of the ten buildings examined was caused by the use of a non-compatible brick, relaxation of construction procedures and the lack of a maintenance program.
6. Weather exposure conditions over a 14-year period in St. John's were not as severe as those used in water permeability tests at the National Bureau of Standards.

REFERENCES

1. Catalog 1958. Brisk Waterproofing Company Inc., 103 Park Avenue, New York 17, N.Y.
2. C.C. Fishburn. Tests of Cement-Water Paints and Other Waterproofings for Unit Masonry Walls. BMS Report 95, National Bureau of Standards, Washington, D.C.

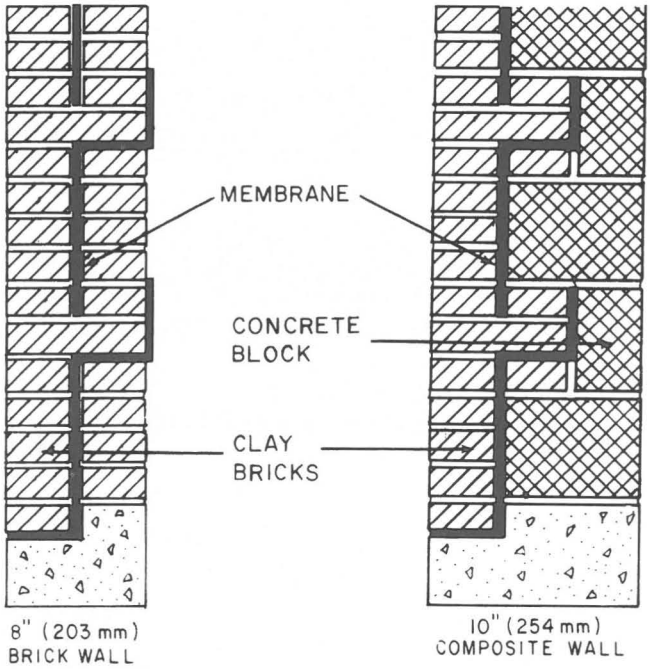

Figure 1. Larson waterproofing system

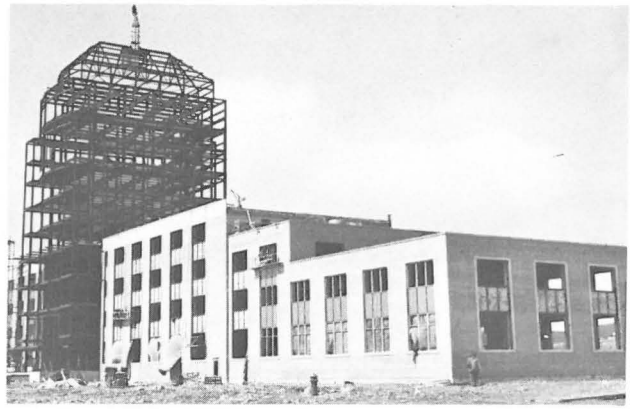

Figure 3. 1959
Confederation Building

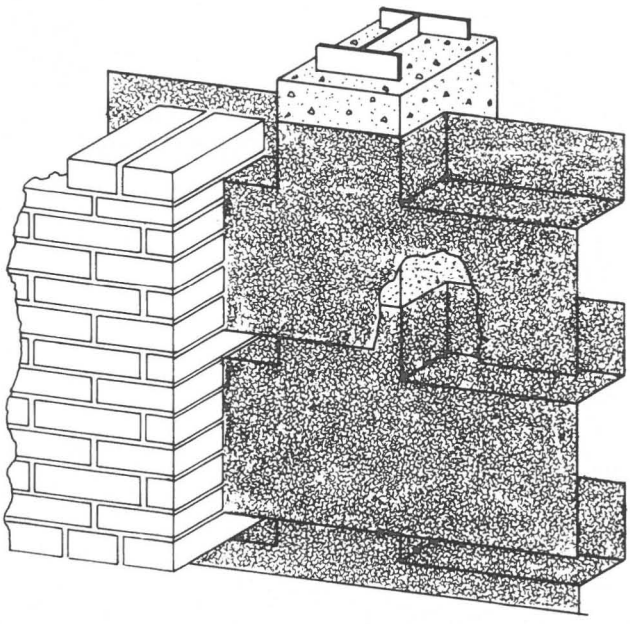

Figure 2. Larson Waterproofing system—sheathing of exterior columns

Figure 4. 1977
Newfoundland and Labrador College of Trades and Technology—Front of building—Efflorescence

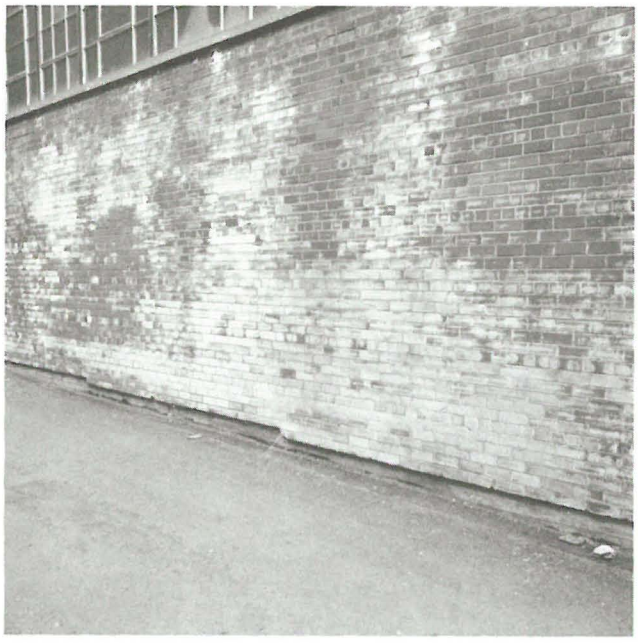

Figure 5. 1977
Newfoundland and Labrador College of Trades and Technology—Severe efflorescence

Figure 6. 1977
Newfoundland and Labrador College of Trades and Technology—Deterioration under windows