CMHC RESEARCH PROJECT

EXTERIOR INSULATED FINISH SYSTEMS

EIFS

FIELD PERFORMANCE

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CMHC STATEMENT

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under Part IX of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has a statutory responsibility to make available information which may be useful in the improvement of housing and living conditions.

This publication is one of the many items of information published by CMHC with the assistance of federal funds.

DISCLAIMER

This study was conducted by Building Envelope Engineering for Canada Mortgage and Housing Corporation under Part IX of the National Housing Act. The analysis, interpretations, and recommendations are those of the consultants and do not necessarily reflect the views of Canada Mortgage and Housing Corporation or those divisions of the Corporation that assisted in the study and it's publication.

EXECUTIVE SUMMARY

Exterior Insulation and Finish Systems (EIFS) are composite cladding systems of plastic foam insulation attached to the exterior of a building, finished with thin glass reinforced synthetic stucco. This study evaluated the field performance of several existing EIFS installations in Canada.

Twenty-five different existing installations were investigated. They were located in the Vancouver, Rocky Mountain, Calgary, Edmonton, and Toronto regions. The EIFS applications had been in service from 2 to 13 years. Most were of the *soft coat* type (Type PB), with thin, relatively flexible acrylic polymer stucco finish over polystyrene insulation. Retrofit installations on older buildings, and buildings originally incorporating the finish, were both included. Each installation was visually examined for signs of distress or deterioration. If close examination was not possible from the ground, binoculars, a spotting scope, and, in most cases, a bosun's chair were used. Photographs were taken of each type of problem encountered at each installation. Building owner's, occupants, and managers were interviewed, and the working drawings were examined in most cases. When it was possible, the interior was examined for signs of damage, where there appeared to be problems on the exterior.

In ten cases, representative samples of the insulation and finish were taken for laboratory analysis. Samples were examined to determine lamina weight, thickness of finish and base coats, water absorption, polymer type and amount, and reinforcement. They were weighed, measured, examined microscopically and photographed. Visible anomalies were reported. Polymer was extracted by solvent and compared by infra-red spectrophotometry with spectra of known polymers. Amounts of polymer and reinforcement were determined by weight, after pyrolysis. Total lamina weight ranged from 2.7 to 7.5 kg/m^2. Average polymer content was 11.8% of the total lamina weight, and ranged from 9.5 to 14.6%. Base and finish coats were observed as thin as 0.1 mm and as thick as 4.0 mm. Weight of a layer of reinforcement was 0.13 kg/m^2 with little variation (excluding added layers of impact resistant mesh), but types and amount of polymer coating on reinforcement varied widely, with no coating at all in two cases.

The finish was in excellent condition in many cases, including the oldest installation observed, on a high-rise apartment building. More than half of the installations were in good to excellent overall condition, although none were entirely free of defect. Approximately 30% had visible problems serious enough to threaten serviceability. Impact damage and ingress of moisture into the system were the most common causes of damage serious enough to demand repair or replacement.

Problems observed in the field included: failed joints, cracking, impact damage, excessively thin applications, softening, erosion of the finish, delamination, poor attachment, fading, freezing during construction prior to cure, color variation, cracking at locations of movement in underlying supports, unsatisfactory repairs, algae and moss growth on the surface, water saturated insulation, damage from interior water sources, and complete detachment of the system from the building.

Greater care in design and installation will help to eliminate some problems. Problems seem particularly likely to arise when the system is substituted at the last moment for some other finish. The finish should be avoided when impact resistance is a requirement, where vehicles, movement of materials, shopping carts, unsupervised children, or swing stages for window cleaning may be involved. It is more durable when applied to substrata like concrete and masonry than on steel stud and gypsum drywall. It should not be applied so that it's attachment depends on the integrity of moisture-sensitive substrata.

Systems of the type examined are *face-sealed* systems. If the exterior surface, which is directly exposed to wind, rain and sun, is imperfect there is no second line of defence.

Maintenance requires greater care and attention than with many finishs. Defects which pass without notice except under close-up visual inspection are capable of admitting injurious amounts of water. Without prompt correction, apparantly small defects can cause significant damage. Since the material looks like stucco or concrete, building owners and managers are often unaware of this.

RÉSUMÉ

Le parement extérieur isolant est un assemblage composé de mousse isolante de plastique fixé à l'extérieur d'un bâtiment et revêtu d'une mince couche de stucco synthétique renforcé à la fibre de verre. La présente étude évalue la tenue en service de plusieurs installations de ce type au Canada.

Vingt-cinq installations différentes, en service depuis 2 à 13 ans, ont été inspectées dans les régions de Vancouver, Rocky Mountain, Calgary, Edmonton et Toronto. La plupart de ces parements extérieurs isolants sont de type «enduit mince» (à base de polymère), l'isolant de polystyrène étant recouvert d'un mince revêtement de stucco relativement flexible en polymère acrylique. L'étude a porté à la fois sur les parements posés après coup sur de vieux bâtiments que sur ceux posés lors de la construction de l'immeuble. Chacune des installations a été l'objet d'un examen visuel visant à détecter tout signe de dommages importants ou de détérioration. S'il était impossible d'examiner l'ouvrage à partir du sol, des jumelles, un télescope d'observation et, dans la plupart des cas, une sellette ont été utilisés. Chaque type de problème découvert sur chaque ouvrage a été photographié. Les propriétaires, les gestionnaires et les occupants des immeubles ont été interviewés et les épures de presque tous les bâtiments ont été examinées. Dans la mesure du possible, les chercheurs ont examiné l'intérieur des bâtiments pour déceler des signes de dommages lorsque l'extérieur présentait des anomalies.

Dans 10 cas, des échantillons représentatifs de l'isolation et du revêtement ont été prélevés afin de déterminer, en laboratoire, le poids de la lame, l'épaisseur du revêtement et de la couche de fond, l'absorption d'eau, le type et la quantité de polymère de même que la nature du renfort. Ces éléments ont été pesés, mesurés, examinés au microscope et photographiés, et les anomalies visibles ont été enregistrées. Un échantillon de polymère a été prélevé au moyen d'un solvant afin de comparer son spectre par spectrophotométrie de l'infrarouge avec celui d'autres polymères. La pyrolyse a permis de déterminer les quantités de polymère et de renfort selon leur poids. Le poids total de la lame variait entre 2,7 et 7,5 kg/m^2 tandis que la teneur en polymère était comprise entre 9,5 et 14,6 p. 100 du poids total de la lame, soit une moyenne de 11,8 p. 100. L'épaisseur des couches de fond et de finition variait entre 0,1 mm et 4,0 mm. Le poids de la couche de renfort était de 0,13 kg/m^2 et présentait peu de variations (à l'exception du treillis additionnel résistant aux chocs), mais les types et la quantité de la couche de polymère posée sur le renfort variaient largement, au point où l'on a même constaté l'absence de revêtement dans deux cas.

Dans de nombreux cas, néanmoins, le revêtement de finition était en excellent état, même pour le plus ancien ouvrage étudié revêtant une tour d'habitation. Plus de la moitié des ouvrages étaient en bon ou en excellent état, bien qu'aucun ne fût tout à fait exempt de défaut. Environ 30 p. 100 des ouvrages présentaient des problèmes visibles suffisamment graves pour menacer leur tenue en service. Les dommages causés par des chocs et par l'infiltration d'humidité constituent les causes les plus fréquentes de dommages entraînant la réparation ou le remplacement.

Les problèmes observés sur le terrain sont les suivants : défaillance des joints, fissuration, dommages causés par des chocs, application de couches excessivement minces, ramollissement, érosion du revêtement de finition, décollement, fixation médiocre, décoloration, gel durant la construction avant la cure, variation de la couleur, fissuration des zones soumises au mouvement des supports sous-jacents, réparations insatisfaisantes, présence d'algues et de mousse sur la surface, isolant saturé d'eau, dommages causés par de l'eau provenant de l'intérieur et séparation complète de l'ouvrage par rapport au bâtiment.

Une conception et une pose plus soignées contribueraient à éliminer certains problèmes. Ceux-ci semblent particulièrement fréquents lorsqu'on a remplacé le système prévu par un autre à la dernière minute. L'utilisation d'un parement extérieur isolant doit être évitée lorsque la résistance aux chocs constitue un critère d'importance ou en présence de véhicules, de manutention de matériaux, de paniers à provisions, d'enfants laissés sans surveillance ou d'échafaudages volants servant au lavage des vitres. Ce type de parement est plus durable lorsqu'il est appliqué sur un substrat comme le béton ou la maçonnerie plutôt que sur des plaques de plâtre supportées par un mur à ossature d'acier. La solidité de sa fixation ne doit pas dépendre de l'intégrité de substrats sensibles à l'humidité.

L'étanchéité de ce genre de parement est assurée en surface. Par conséquent, lorsque cette surface exposée au vent, à la pluie et au soleil est imparfaite, il n'y a pas d'autre moyen de défense contre les intempéries.

L'entretien de ce système nécessite beaucoup plus d'attention que d'autres types d'ouvrage. Des défauts qui peuvent passer inaperçus sans une inspection minutieuse et qui ne sont pas rectifiés rapidement peuvent laisser passer des quantités d'eau très dommageables. Étant donné que le matériau utilisé ressemble à du stucco ou à du béton, les gestionnaires et propriétaires d'immeubles sont rarement conscients de cette situation.

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INTRODUCTION

Definition

Exterior Insulation and Finish System(s) (EIFS) is the generic name for a building cladding that usually consists of a plastic insulation board, glass fibre reinforcing mesh, and a two-coat synthetic stucco surface. The system is applied over concrete, masonry, sheathing on steel stud framing, or other continuous lateral load-bearing support. The system provides insulation, a relative degree of air tightness, rain resistance and a textured surface coating, all combined into one installation.

An EIFS is constructed of several components. The insulation is usually expanded or extruded polystyrene; however, it can be mineral wool. It is glued and/or mechanically fastened to the support. In current installations, a continuous air seal is often applied first, and the EIFS is mechanically fastened, unless the air seal also serves as adhesive.

A coated fiberglass reinforcing mesh is embedded in trowel-applied base coat, adhering it to the insulation. If fasteners are used, they may secure the mesh as well as the insulation, or the mesh may be applied over them. The mesh is covered with base coat. The base coat and mesh may be applied in 1, 2, or 3 operations.

The finish coat is applied over the base coat to provide decorative surface texture and color. It may be sprayed, but is usually trowelled. Sometimes a primer, matching the finish coat in color, is applied first.

Lamina refers to the combined mesh, base coat, and finish.

At edges and joints the lamina is wrapped around the edge and partway around the back of the insulation. *Soft joints* are formed by placing elastomeric sealant and foam rod between two such *edge wrapped* edges.

EIFS are usually classified into two basic types, although there may be some overlap. The first type is polymer modified or hard coat. It has a thicker base coat which is bound primarily by portland cement paste, modified with polymers. The system is mechanically fastened through extruded polystyrene insulation to the support. Few such applications were found in the field. This system is often mistaken as a conventional stucco coating, and has stiffness and strength similar to stucco.

The most common EIFS is the polymer based or soft coat system, in which acrylic polymers are the primary binder, although hydrated portland cement is also present in the base coat. Polymer based systems are thinner: 2 to 5 mm vs. 10 to 15 mm for polymer modified. The percentage of acrylic polymer is higher: 10% or more vs. 8% or less, and the lamina is more flexible. Polymer based systems are usually applied over cut surfaces of Type 1 or Type 2 expanded polystyrene (EPS beadboard), and secured by adhesion. The insulation is secured to the support with an adhesive similar to the base coat in composition.

The division into two classes may be more artificial than it appears; a continuous range of possible formulations exists between soft and hard. As acrylic resin content is increased, the transition from one to the other is not a sudden step, but gradual, with a region of more rapid transition in the middle. Observed installations included intermediate applications where the lamina was thicker than usual, though fairly flexible, and applied over beadboard; and also where the lamina was relatively thin, although brittle and applied over extruded polystyrene with mechanical attachment.

History

EIFS have been successfully used on buildings in Europe since the Second World War. In North America the first uses were in marine architecture. On North American buildings EIFS usage is more recent, and has evolved in directions different from European usage, where the system originated and has a longer history. Differences between North American and European usage are:

Europe	Canada
Mostly low rise on masonry or concrete	Often high rise on metal stud and gypsum board
Independent testing & certification	Reliance on manufacturer for quality control
Mild climates	Severe winter temperatures
Extensive experience	Limited experience

EIFS have been used in Canada for only 20 years or so. They have many appealing attributes, but lack a long history of successful application in North America.

Previous Research

Before this study was undertaken, Canada Mortgage and Housing Corporation commissioned and issued a report entitled *Problems Causes and Solutions Encountered With Exterior Insulation and Finish Systems.*[1] This report reviewed the literature on EIFS and informally polled the industry.

It came to the following conclusions:

> "A review of the basic performance requirements and design principles related to exterior walls suggests that EIFS claddings may require high levels of workmanship and maintenance to provide reasonable serviceability. EIFS are typically face sealed claddings where the exterior surface and joints must remain weathertight over the service life of the building. The materials used in EIFS in general, and those utilized at the joints in particular, are required to meet very high performance requirements due to their exposure to wind, rain, thermal cycling and solar radiation over a prolonged period of time. It is possible that in many cases the need for higher performance face sealing is compounded by the properties of the EIFS materials and the supports upon which they are mounted.
> Damage to EIFS claddings may result from water penetration, moisture during construction, or in some instances moisture condensing on the back of the sheathing on which the cladding system is mounted. Moisture related deterioration maybe exacerbated when claddings are installed over support surfaces that are sensitive to moisture. One of the most common supporting surfaces is exterior gypsum board sheathing attached to steel studs with screws. In most cases the EIFS cladding is adhered to the face of gypsum sheathing. This type of construction can result in the entire cladding system of a high rise building relying on the integrity of the gypsum core and/or the paper facing of the gypsum sheathing. In instances where no mechanical fasteners are used in the EIFS, as is often the case, any moisture related softening of the gypsum board sheathing and/or corrosion of the screw attachments of the sheathing to studs could result in significant loss of integrity of the cladding system.
> Though the present extent and severity of moisture related deterioration that maybe affecting in-service EIFS claddings has not been established concern has been expressed in some quarters, but no definitive studies have been undertaken. There is no consensus on the long term serviceability of EIFS.

1. Christopher Mattock, *Exterior Insulation and Finish Systems (EIFS) Problems, Causes and Solutions*, Habitat Design & Consulting, Vancouver, May 30, 1991 (CMHC File No. 6585/M83-1).

It is recommended that the following steps be taken:

- Carry out field investigations of EIFS that are presently in service ranging in age from 1 to 20 years to investigate the extent and severity of potential problems, if any. These investigations should be undertaken in as wide a range of climatic zones as possible i.e. in the Pacific maritime, Prairie, Central and Atlantic maritime regions.
- Have the results of the field investigations reviewed by the EIFS industry, building envelope specialists, designers and CMHC.
- If warranted, based on the results of the field investigations and review, carry out more detailed field and or laboratory investigations to establish the effects of condensation, wind, solar radiation, thermal cycling and rain on the performance of EIFS.
- Investigate modifications to EIFS design and construction that would counter any problems if identified in the field and or laboratory investigations.
- With the cooperation of the EIFS industry develop a series of guidelines for manufacturers, installers and designers that would enhance the performance of EIFS."

The present study was undertaken as a result of these recommendations.

Properties of EIFS

Advantages

The typical EIFS has a number of properties which appeal to building designers. A wide variety of colors, textures, shapes and design effects can be achieved. Making reference to past architectural styles, or creating a new one, is almost as easy with an EIFS as creating a plain unadorned surface. Further EIFS advantages include:

- design versatility
- aesthetic appeal
- light weight
- high possible R-Value with minimal impact on other components
- minimal thermal bridging
- suitability for recladding, particularly over uninsulated concrete, masonry and stone
- completion from exterior, with minimal interior disruption
- choice of field or prefabricated panel installation
- relatively low cost
- single trade responsibility

EIFS claddings can be installed over large areas with minimum joints, at least in some cases. One continuous 24 storey span of EIFS adhered to a monolithic concrete wall, with no cracks after more than a decade of service, was observed.

Although combustibility of EIFS has been, and is still a controversial issue, fire safety requirements of most building codes can be met for a wide variety of non-combustible buildings.[2]

2. Fire safety and combustibility issues are outside the scope of this study. For further information refer to *Code Clarification on EIFS Cladding* in NRC's CCMC News, Winter '93 (Issue No. 4), ISSN 0848-600X.

Design Parameters

EIFS materials have several important properties which have to be understood and accommodated for successful application.

Most Canadian high-rise cladding design is based on the pressure equalized rain screen, or cavity wall system. The rain screen system tolerates imperfections in the exposed surface and has provided better weather protection than older face seal designs constructed with the same materials. An EIFS is a face sealed system; it requires perfection in the outer seal, if wind-driven rain is to be excluded. The critical components are directly exposed to sunlight, precipitation, and extreme temperatures. Once any component is reduced from perfection, the system does not perform as required.

Unlike stucco and many other claddings, EIFS installations do not lend themselves to full *rain screen* design (including a capillary break as well as pressure equalization) without substantial cost increase, so small defects assume great significance, especially on large exposed surfaces in high-rise construction.

The finish coat is not waterproof; it is the base coat which provides the waterproofing. If the reinforcing mesh is not covered front and back, small pressure differences will drive water through the finish into the insulation.[3]

If kept constantly wet, the finish coat will usually soften, swell, lose strength, and may debond from the base coat.

Fiberglass reinforcement is inherently susceptible to alkali attack. Invisible deficiencies in the polymer coating of the glass fibres in the mesh may allow alkali in the base coat to corrode the surface of the glass fibres, creating fracture initiation sites which result in substantial strength loss. Free lime from hydration of portland cement in the base coat provides ample opportunity when moisture is present, unless the formulation of the base coat itself coats the glass with a protective polymer film.

The wide spacing of joints which is possible depends on uniform restraint of the finish by the insulation, preventing free thermal movement of the lamina. When the system is functioning properly, thermal changes which would otherwise cause differing amounts of movement in the lamina, insulation, and support, are expressed as stress, not strain. Inadequate edge restraint (edge wrapping), and points of stress concentration (e.g. corners of openings) can lead to expressions of strain instead, in the form of cracks.

The system is breathable, relative to a good vapor barrier, but less breathable than many other airtight materials. It's permeance is less than half that of building paper, and about a quarter that of solid unfinished gypsum board. It is not sufficiently permeable to permit removal of significant amounts of water by evaporation at the surface. Once water gets into the system, it is difficult for it to get out, unless there are cracks or other imperfections through which it can drain.

Long term performance of EIFS, as used in North America, is yet to be proven. Independent of this study, the authors have seen EIFS, installed in the late 60's, in which the finish delaminated completely from the insulation within 10 years. In other instances, water has been observed to soften and erode the finish coat in as little as a year. In contract, some installations appear virtually as good as new after 15 years.

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3. Piper, Richard S. & Raab, Susanne; *Factors Affecting the Water Resistance of EIFS Base Coats and Insulation Board*, ASTM *International Symposium on Exterior Insulation and Finish Systems (EIFS): Performance of EIFS Worldwide*, September 21-24, 1992, Arlington VA.

PURPOSE & METHODOLOGY

EIFS have undoubtedly been refined over the years, but the doubts raised in the Habitat report, and the problems which the authors and others have seen, were enough to warrant closer examination of actual in-service conditions in Canada.

A research program, with proper experimental design and statistical analysis, was not contemplated. It was possible to examine some buildings in greater detail than others. The sample examined included so few buildings of any particular type that quantitative results may be misleading, either by chance, or by design in the case of buildings selected because of known problems. While a reliable estimate of the frequency of occurrence of any particular problem could not be made, most of the spectrum of possible problems was probably observed.

In review of the observations, informed judgements on what problems are likely to occur with particular materials, systems, and assemblies; how often they are likely to occur; and how extensive the resulting damage is likely to be have been made. The recommended directions for further research, and recommendations for design of future installations, are based on these judgements.

Lists of potential buildings were obtained from various manufacturers, contractors and designers in the EIFS industry, as well as from CMHC. From this list, building owners were contacted to verify that an EIFS had been used and to obtain permission to examine and report on their buildings. In some cases, permission to take samples for laboratory analysis was obtained.

On-site Evaluation

Twenty-three EIFS-clad buildings that had been in service for 2 to 13 years, in Toronto, Calgary, Edmonton, Vancouver, and the mountain regions of B.C. & Alberta were examined.

It was not possible to examine all buildings in the same detail. All cases included a general overall inspection of the building from the exterior, to observe the general condition of the cladding and discover any visible problems, with the assistance of binoculars and spotting scope. Records inluded general photographs, detailed photos of each type of problem observed, and notes of what could be seem of the materials and assemblies used in construction.

In addition to this general overall inspection of the building from the exterior, the following evaluation sequence was included, so far as possible:

- meeting with building manager to examine original drawings, specifications and maintenance records, discuss his experience, and identify any known problems;
- asking building occupants if they knew of any problems;
- examining the exterior of one or more locations, including identified problem areas, from a bosun's chair, or from ladders and balconies;
- examining the interior, where problems were evident on the exterior, for signs of water damage, and for possible causes;
- removing interior finish to examine the back of the sheathing supporting the cladding (only possible in one case); and
- removing a representative sample (not from a problem area unless the problem was more or less typical).

Where samples of the EIFS were removed, the sections were repaired with urethane foam and louvered plates, to avoid matching difficulties and application in unsuitable weather.

Laboratory Tests

Ten samples of polymer based EIFS were taken for laboratory analysis. Two of these came from the same installation. All samples were measured and analyzed for:

- lamina weight (total lamina mass per unit area)
- thickness (finish coat & base coat)
- water absorption (% of lamina mass)
- qualitative evaluation of adhesion, porosity, and defects
- polymer (type and % of lamina mass)
- reinforcement (types an % of lamina mass)

One sample of unreinforced coating (applied without glass reinforcement directly on concrete) and two samples of resin coated glass mesh were also analyzed. One of the samples of mesh had not been coated with base coat. The other was separated from the base coat relatively easily, an impossible task with typical samples.

The number of samples obtained was not sufficient to provide statistical significance, however it provides some indication of the variation.

Testing of the samples was completed by George C. Hawley & Associates of Montreal.

Methodology

The samples were examined microscopically. The thickness of finish coat and base coat layers (including reinforcement) was determined. The samples were inspected for anomalies including excess porosity, cracking and delamination.

Water absorption was determined after soaking samples in water at 38 °C for four hours. None of the samples showed any obvious signs of softening or deterioration, an indication that longer test exposure might have been appropriate.

Polymer was extracted by solvent and identified by infra-red spectrophotometry. Polymer not removed by solvent extraction was removed by pyrolysis, to determine total polymer mass per unit area. Glass reinforcement content was determined by removing and weighing glass fibre after pyrolysis, hence resin coating on glass mesh is included in polymer content, and not in the reinforcement mass.

Results

Individual test results are summarized with the observations for each corresponding building. All of the coatings sampled were polymer-based, rather than polymer modified. Overall findings are summarized as follows:

Property	Average	Range	Measure
Lamina weight	5.0	2.7 - 7.5	kg/m^2
Polymer content	11.8	9.5 - 14.6	%
Water absorption	7.1	2.7 - 10.1	%
Min. base coat	0.9	0.1 - 2.5	mm
Max. base coat	1.3	0.2 - 3.2	mm
Min. finish coat	0.4	0.1 - 1.5	mm
Max. finish coat	1.7	0.75 - 4.0	mm
Reinforcement[4]	3.4	2.0 - 4.7	%
Reinforcement	0.13	0.11 - 0.14	kg/m^2

The samples included several types of mesh. Except for an added layer of impact resistant mesh in one instance, mesh warp and weft were spaced at 4.25 mm centres in all samples. The mesh from two samples appeared to have no polymer coating. The remaining samples were coated with yellow, blue, white or clear polymer coatings.

In general the samples were reported as being of good quality, conforming to the EIMA Guideline Specifications[5], with a few exceptions. The exceptions are noted with the observations for each building.

4. Not including any overlaps, or the additional layer of heavy mesh in one sample.
5. *EIMA Guideline Specification for Exterior Insulation and Finish Systems, Class PB*, Exterior Insulation Manufacturers Association, Clearwater, FL, 1991.

OBSERVATIONS

In the descriptions which follow, unless noted otherwise, all buildings had lamina reinforced with glass fibre mesh, used polymer-based base coat, and were insulated with polystyrene beadboard.

BUILDING 1 High Rise Residential

Location	Calgary
EIFS height	27 storeys
Interior humidity	moderate (except high on one floor)
Age of structure	13 years
Age of EIFS	13 years
Insulation thickness	38 mm
Substrata	concrete, concrete block, and gypsum board
Fastening	adhesive
EIFS drawings	architectural
Fabrication	on-site
Cracks	moderate
Joint problems	none (very few soft joints)
Moisture problems	minor
Impact damage	minor
Sample location	beside impact damaged area, facing North, near grade
Lamina weight	3.1 kg/m²
Polymer content	10.2%
Water absorption	7.2%
Base coat thickness	0.5 - 0.75 mm
Finish coat thickness	0.1 - 2.0 mm
Reinforcement	0.12 kg/m²

Most of the EIFS cladding was constructed as a rain screen consisting of the EIFS, gypsum sheathing, and steel stud framing; with a cold air space, vented outdoors, between it and the insulated structure. Cracks occurred at most reentrant corners, and also in one large unjointed panel (a *reentrant* corner is an inside corner of an opening which returns towards the interior, such as at a punched window opening). The corners are areas of high stress, which tend to crack. One section of the EIFS, extending from the 6th to the 27th floor, was not a rain screen. It was bonded directly to a concrete shear wall, and was free of cracks, even though there were recessed false joints in the surface. This wall faced away from prevailing driving rains, and did not adjoin any normally occupied interior spaces. The building manager reported no leaks which he could attribute to the EIFS.

In limited areas, the acrylic finish coat was applied directly to edges and soffits of concrete balconies. Moisture had penetrated through cracks in the concrete and caused some staining and delamination of this finish.

Impact damage had occurred at grade along an alley and at a loading dock due to contact with vehicles and trash bins. These areas were the only areas near grade; most other EIFS was at shoulder height or above. Impact damage had also occurred several stories above grade in a few places, from swing staging used for cleaning windows.

Laboratory investigation of the sample reported no defects or anomalies.

BUILDING 2 Recreation Complex

Location	Calgary
EIFS height	1 storey
Interior humidity	high (swimming pool)
Age of structure	9 years
Age of EIFS	9 years
Insulation thickness	50 mm
Substrata	concrete block and concrete
Fastening	adhesive
EIFS drawings	architectural
Fabrication	on-site
Cracks	minor
Joint problems	none
Moisture problems	none
Impact damage	moderate

The walls were divided into rectangular panel sections, with soft joints spaced at 10 m intervals. The EIFS finish was all located at or near grade. The cladding was free of cracks except the few reentrant corners. The perimeter of the building was decorated with gravel, thrown at the wall by vandals and embedded in the EIFS.

BUILDING 3 Shopping Centre

Location	Calgary
EIFS height	1 storey
Interior humidity	low
Age of structure	approx. 5 years
Age of EIFS	approx. 5 years
Insulation thickness	50 mm
Substrata	concrete block and gypsum board
Fastening	adhesive
EIFS drawings	unknown
Fabrication	on-site
Cracks	moderate
Joint problems	moderate
Moisture problems	minor
Impact damage	minor

This building was decorated with recessed panels and varied colors. The EIFS at ground level, with conventional reinforcement, was damaged by shopping carts. Cracks were observed at some reentrant corners, false joints, in mid-panel and at penetrations. Major cracks were observed where the EIFS spanned across independent building structures without any joint. One section of the EIFS appeared to be debonded due to moisture flow through the wall. Moisture appeared to have entered through a cap flashing into the EIFS insulation. There were small cracks rimmed with efflorescence, some aligned with the joints in the insulation. The pattern of the insulation joints was evident as discoloration and cracking in the surface in this area.

BUILDING 4 Hotel, Rocky Mountain Region

This building, located in the Front Range of the Rocky Mountains had several wings, of varying ages, which had been clad at different times with different EIFS. Three parts of the building were evaluated.

Building 4A

EIFS height	9 storeys
Interior humidity	low
Age of structure	more than 50 years
Age of EIFS	8 years
Insulation thickness	89 mm
Substrata	masonry & concrete
Fastening	adhesive
EIFS drawings	architectural
Fabrication	on-site
Cracks	moderate
Joint problems	minor
Moisture problems	major
Impact damage	minor
Sample location	EIFS from Northwest exposure, plus pieces of finish coat only on concrete
Lamina weight	7.5 kg/m^2
Polymer content	10.4%
Water absorption	6.0%
Base coat thickness	1.0 - 1.9 mm
Finish coat thickness	1.5 - 4.0 mm
Reinforcement	0.13 kg/m^2/layer (2 layers at sample location)

The building was retrofitted with an EIFS. It was originally uninsulated. Existing concrete and masonry was wrapped with metal mesh, mechanically fastened, on which a levelling portland cement-based coat was applied. The EIFS was adhered to the resulting surface.

The EIFS had experienced extensive delamination of the finish coat where it had been in frequent contact with snow or water, and where ice had adhered to it. The finish coat had also been applied directly to concrete in limited areas, and had delaminated severely in those locations. Impact damage had occurred due to sliding snow on roofs adjacent to EIFS clad walls. Moisture flow from the roof into the EIFS at the roof/wall junction contributed to discoloration and delamination of the lamina. Cracks rimmed with efflorescence and delamination, especially at bottom edge wrapping, both occurred. Failure of soft joints occurred due to delamination of finish coat on the sides of the joints. Numerous cracks were observed at reentrant window corners.

Building 4B

EIFS height	1 Storey
Interior humidity	low
Age of structure	2 years
Age of EIFS	2 years
EIFS type	polymer modified
Insulation thickness	50 mm
Insulation type	extruded polystyrene
Substrata	peel and stick membrane on concrete and gypsum board
Fastening	mechanical
EIFS drawings	not available
Fabrication	on-site
Cracks	minor
Joint problems	none
Moisture problems	none
Impact damage	minor

This building was clad with a polymer modified system. Some cracking was observed at reentrant corners. Repairs to a section frozen during construction did not match the prevailing color and texture. There was less impact damage than would be expected with a polymer based system.

Building 4C

EIFS height	9 storeys
Interior humidity	low
Age of structure	5 years
Age of EIFS	5 years
Insulation thickness	100 mm
Substrata	gypsum board
Fastening	adhesive
EIFS drawings	none
Fabrication	on-site
Cracks	moderate
Joint problems	major, at building expansion joint, otherwise minor
Moisture problems	none
Impact damage	minor
Sample location	South-facing wall, near grade.
Lamina weight	4.5 kg/m^2
Polymer content	10.6%
Water absorption	8.2%
Base coat thickness	1.0 - 1.2 mm
Finish coat thickness	0.2 - 2.5 mm
Reinforcement	0.14 kg/m^2

Cracks were observed at reentrant corners and occasionally at mid-panel insulation joint lines. Cracks were wider than usual in one area, and connected window corners on one floor to window corners and penetrations on the floor below. Another area, reported to have been damaged by flooding from the interior, had been repaired. Difficulty in matching color and texture was evident. The sample was taken from an edge where the edge-wrapping had not been coated with base or finish coat.

Laboratory investigation of the sample reported no defects or anomalies in the lamina. Adhesive coverage on the back of the insulation was approximately 10%. The mesh at the edge allowed a determination of the amount of organic material in the mesh coating, independent of the polymer in the base and finish coats. The polymer coating was not identified (hence not acrylic, vinyl acetate, or styrene butadiene). The percent extracted by solvent was 17.2% by weight of the mesh. A further 1.2% was removed by pyrolysis.

BUILDING 5 Recreation Centre

Location	Calgary
EIFS height	2 storeys
Interior humidity	moderate to high (swimming pool, ice rinks)
Age of structure	11 years
Age of EIFS	11 years
Insulation thickness	50 mm
Substrata	concrete block, concrete and (in very limited areas) gypsum board
Fastening	adhesive
EIFS drawings	architectural
Fabrication	on-site
Cracks	minor
Joint problems	minor
Moisture problems	minor
Impact damage	major
Sample location	North-facing wall
Lamina weight	4.0 kg/m²
Polymer content	10.9%
Water absorption	8.9%
Base coat thickness	0.5 - 2.0 mm
Finish coat thickness	0.5 - 2.0 mm
Reinforcement	0.13 kg/m² (after correction for overlap on part of sample)

The building was clad in a three tone color scheme, with patterns of recessed false joints to give an impression of depth. Cracking occurred through some false joints. Wall sections adhered to concrete were free of cracks. Two large cracks and a soft joint failure occurred where the EIFS bridged independent structures. Some sections had collected dirt and were discolored by water running down from joints in flashings. It appeared that some chalking of darker colors had occurred, especially on southern exposures. A section of EIFS bonded to gypsum board, which was directly in contact with high humidity on the interior surface, showed no signs of any deterioration on the exterior. The back of the sheathing was mildewed, and appeared to have been wetted periodically. The interior gypsum board was moderately moisture damaged. The location was immediately adjacent to a direct air leak. It appeared that conditions would have been worse if the air leak had been less direct. Several areas of the building had been extensively damaged by vandals throwing rocks and kicking the surface. Some rocks remained embedded in the insulation. Several repairs had been made which did not succeed in matching the surrounding surface. Graffiti had been successfully painted over. Some damaged areas on North-facing walls near grade were supporting growths of moss.

The sample was taken at a location where base coat had pushed about 5 mm into a 3 mm wide gap between insulation boards. The mesh was overlapped at the same location. There were no cracks over the joint.

BUILDING 6 High Rise Residential

Location	Vancouver
EIFS height	19 storeys
Interior humidity	moderate
Age of structure	approx 4 years
Age of EIFS	approx 4 years
Insulation thickness	unknown
Substrata	gypsum board
Fastening	adhesive
EIFS drawings	not available
Fabrication	on-site
Cracks	minor
Joint problems	minor
Moisture problems	none visible externally
Impact damage	minor

The building was two apartment towers, reputedly completed during cold temperatures. No information was obtained from the owner. Inspection from the exterior did not locate any indication of moisture problems, excessive cracking or finish problems. Kitchen exhaust louvers directing air at the surface finish had significantly discolored the surface in several locations. Patches where ties had secured scaffolding during construction were not well matched in texture to surrounding surfaces.

BUILDING 7 Hotel

Location	Coastal Mountains, B.C.
EIFS height	8 storeys
Interior humidity	moderate
Age of structure	4 years
Age of EIFS	4 years
Insulation thickness	50 mm & 75 mm
Substrata	gypsum board
Fastening	adhesive
EIFS drawings	architectural
Fabrication	on-site
Cracks	minor
Joint problems	minor, except for serious failure in expansion joints.
Moisture problems	minor
Impact damage	minor

The EIFS cladding was generally in good condition with the exception of a few areas. Soffits, clad with EIFS, indicated moisture seepage through the face from the insulation. Reinforcing mesh was visible through the finish coat in one area. Metal stud walls were filled with batt insulation and clad with an EIFS. In some areas the insulated metal stud wall was separated by a space from the EIFS cladding. These spaces could not be accessed for examination. There was no intentional venting to either interior or exterior. There was no visible evidence of condensation related damage on the exterior of the wall, but staining of soffits suggested condensation in some concealed spaces. The interior of the wall could not be examined. Small pieces of finish coat had debonded from the base coat where there had been contact with snow. Only 1 out of 20 reentrant corners had cracked. Two locations were observed where incomplete caulking of soft joints contributed to moisture flow through the EIFS, resulting in significant interior damage, and damaging the lamina in those isolated locations. Frost on the exterior wall surfaces showed patterns at stud and insulation joint locations.

BUILDING 8 High Rise Residential

Location	Edmonton
EIFS height	24 storeys
Interior humidity	moderate
Age of structure	10 years
Age of EIFS	10 years
Insulation thickness	25 mm
Substrata	gypsum board
Fastening	adhesive
EIFS drawings	architectural
Fabrication	panellized and on-site
Cracks	moderate
Joint problems	minor at soft joints EIFS to EIFS
Moisture problems	major
Impact damage	minor

The building had experienced major water leakage through the walls and windows for several years. The walls were metal studs with batt insulation, clad with thin insulation and EIFS lamina. A majority of the water leakage into the walls was due to rain penetrating through the windows and perimeter caulking to the EIFS. Some condensation had occurred due to the combination of dew point within the batt insulation, and greater air tightness of the EIFS compared to the interior finish. Failure of soft joints was limited to a few locations where the finish coat had debonded from the base coat. Moisture had severely damaged the exterior gypsum board and fasteners.

BUILDING 9 Hotel

Location	Toronto
EIFS height	9 storeys
Interior humidity	low
Age of structure	7 years
Age of EIFS	7 years
Insulation thickness	100 mm
Substrata	concrete, concrete block, and gypsum board
Fastening	adhesive
EIFS drawings	architectural
Fabrication	panellized and on-site
Cracks	moderate
Joint problems	minor
Moisture problems	minor
Impact damage	minor

Most of the EIFS was panellized, with gypsum board as a backup material and a cold air space between the panel and the insulated interior wall. The space was vented with small PVC tubes. Site-built metal stud walls behind the panels were insulated with batt insulation. Window sills, constructed of sloped EIFS 600 mm wide, were sound and generally free of cracks or visible moisture damage. Site applied EIFS was primarily over concrete or concrete block, and displayed minimal cracks. Joints between panels were usually 2-stage, sealed with caulking at the back and face. Joint spaces were vented with small PVC tubes. Moderate impact damage was observed in the loading dock area, due to impact with pallets and crates, and in one other location due to landscape maintenance. The heavy duty mesh used in the dock area was not sufficient to withstand the impacts. Windows were detailed to minimize reentrant corners. Some caulking failures appeared to be due to inadequate mixing of 2-part sealant. Sealant failed in cohesion at building expansion joints. Sealant failure between EIFS panels was minimal. One wall panel had contrasting finish which appeared to have been damaged. Limited areas had long vertical cracks in mid-panel (in site-applied sections).

BUILDING 10 Office Building

Location	Toronto
EIFS height	4 storeys
Interior humidity	low
Age of structure	5 years
Age of EIFS	5 years
Insulation thickness	50 to 150 mm
Substrata	concrete block and concrete
Fastening	adhesive and mechanical
EIFS drawings	none
Fabrication	on-site
Cracks	numerous, major
Joint problems	few EIFS to EIFS, moderate EIFS to window frames
Moisture problems	moderate
Impact damage	minor
Sample location	South-facing wall (10A), plus one weathered piece of lamina only found on the roof (10B)

Sample 10A

Lamina weight	4.0 kg/m²	
Polymer content	9.5%	
Water absorption	10.1%	
Base coat thickness	Layer 1:	0.1 - 0.2 mm
	Layer 2:	1.2 - 1.5 mm
Finish coat thickness	0.2 - 1.0 mm	
Reinforcement	0.13 kg/m²	

Sample 10B

Lamina weight	5.2 kg/m²	
Polymer content	12.3%	
Water absorption	6.1%	
Base coat thickness	Layer 1:	0.75 - 1.0 mm
	Layer 2:	0.75 - 1.0 mm
Finish coat thickness	0.5 - 0.75 mm	
Reinforcement	0.13 kg/m²	

Two faces of the building were clad with EIFS. The architectural drawings indicated a portland cement plaster on lath over a vented and drained space, with insulation behind. The use of an EIFS seems to have been a last minute change, adopted without working out formal drawings or details. The installed base coat was continuous; there were no soft joints except at window junctures. False joints were constructed by taping over the white base coat, applying colored finish coat and removing the tape. Were the sample was removed, the insulation was quite thick; one layer about 100 mm thick over another layer about 50 mm thick with no adhesion between them, both mechanically fastened to the support. The only problems reported by the owner were water leakage through the perimeters of some punched windows. There was no evidence of any flashing at the head of the window to intercept water which might be travelling down through the insulation.

Tensile cracks in the lamina were very common on this building. They were located at most reentrant corners, and occurred at some mid panel locations, penetrations and support transitions. One system of cracks was associated with a change of support from cast-in-place concrete to non-loadbearing concrete block masonry infill. Light fixtures were open to rainwater drainage from the surface into the EIFS. Perimeter caulking was poorly installed.

BUILDING 11 High Rise Residential

Location	Toronto
EIFS height	28 storeys
Interior humidity	moderate
Age of structure	approx 30 years
Age of EIFS	approx 8 years
Insulation thickness	50 mm
Substrata	sand-lime brick
Fastening	adhesive
EIFS drawings	none
Fabrication	on-site
Cracks	numerous
Joint problems	water accumulated behind sealant, few sealant failures
Moisture problems	major
Impact damage	minor
Sample location	Northeast-facing wall
Lamina weight	6.9 kg/m^2
Polymer content	12.4%
Water absorption	2.7%
Base coat thickness	2.0 - 2.25 mm
Finish coat thickness	1.0 - 1.5 mm
Reinforcement	0.11 kg/m^2 per layer (2 layers at sample location)

This EIFS was applied by adhesion to existing brick which had previously suffered freeze/thaw damage. The owner reported that the original wall construction was interior plaster on 25 mm of extruded polystyrene insulation on 100 mm concrete block faced with 100 mm sand-lime brick. At the floor slabs, the slab edges were exposed on the exterior, and supported the masonry walls. When the EIFS was installed, caulked joints were installed at every floor line, in line with the underside of the slab and aligned with the window head. Cracking in the field of the lamina was extensive. It also occurred at corners; 18 out of 20 reentrant window corners exhibited cracks, starting at the corner and extending vertically, horizontally, or at 45 degrees. Many of these corner cracks were longer than usual; some up to 1200 mm or so in length, and extended to an edge or joint. In the sample, and in samples previously removed by the Owner, the adhesion of the insulation was strong enough to have removed some of the brick surface, possibly where it was previously frost damaged. Insulation and polyethylene foam rod in joints were saturated with water trapped behind the sealant at several locations. Examination of the interior failed to turn up any moisture, although there were signs of past moisture damage in the plaster around and below windows, and in wood flooring at the base of the wall. The exterior insulation was very wet.

Vertical caulked joints were in good condition. The most probable water entry mechanism was through the lamina from the exterior, rather than condensation of interior moisture or entry through failed joints. Reinforcement was visible in the finish in several locations, and cracks tended to be along the lines of the warp or woof of the mesh, with transitions sometimes occurring at right angles from one strand to an adjacent parallel strand. All samples had wide joints between pieces of insulation, partly filled with base coat. Cracks in line with these filled joints were common and wider than the typical cracks over strands in the reinforcement.

BUILDING 12 High Rise Residential

Location	Toronto	
EIFS height	28 storeys	
Interior humidity	moderate	
Age of structure	approx 25 years	
Age of EIFS	approx 5 years on end wall, 3 years on side walls	
EIFS type	polymer based, approx 3 mm thick on end walls; 6 mm thick on side walls	
Insulation thickness	50 mm on end wall; 75 mm on side walls	
Insulation type	EPS beadboard on end wall; extruded polystyrene on side walls	
Substrata	sand-lime brick; with textured coating on end wall, uncoated on side walls	
Fastening	adhesive on end walls; mechanical on side walls	
EIFS drawings	none	
Fabrication	on-site	
Cracks	minor	
Joint problems	minor	
Moisture problems	moderate on end wall, not evident on side walls	
Impact damage	none	
Sample location	end wall, Northeast facing	
Lamina weight	5.7 kg/m²	
Polymer content	14.0%	
Water absorption	5.7%	
Base coat thickness	Layer 1:	1.1 - 1.3 mm
	Layer 2:	0.5 - 0.6 mm
	Layer 3:	0.1 - 0.3 mm
Finish coat thickness	0.1 - 1.5 mm	
Reinforcement	0.11 kg/m²	

The original wall construction was like that of Building 11, except that shelf angles instead of slab edges supported brick. The brick was surface spalled in some areas by freeze-thaw. Different treatments, including 2 different EIFS cladding systems, had been applied.

On the end wall EIFS was applied by adhesion to existing brick which had been coated with an exterior textured coating. Fifty millimeters of EPS beadboard was added by adhesion with intermittent dabs, yet the sample was difficult to remove. Horizontal joints were located at each floor, sealed with a double bead of sealant. Bondbreaker rod within horizontal soft joints was damp. No external deterioration of the EIFS was seen.

On the side walls no textured coating had been applied. When the EIFS retrofit was done, peel and stick membrane was applied and extruded polystyrene was mechanically attached to the masonry, through the EIFS reinforcing mesh. Soft joints were provided at every floor line. Most panels were rectangular, without reentrant corners. Only two of 20 reentrant corners were cracked. Cracks were generally less than 100 mm in length. Some rust-like staining of the lamina aggregate was observed. It was reported that window sill flashings may have been installed after the EIFS, contributing some moisture to the cladding, but no damage was evident. No external deterioration of the EIFS was seen.

BUILDING 13 High Rise Residential

Location	Toronto
EIFS height	28 storeys
Interior humidity	moderate
Age of structure	approx 25 years
Age of EIFS	3 years
EIFS type	polymer based, thick
Insulation thickness	75 mm
Substrata	sand-lime brick
Fastening	mechanical
EIFS drawings	none
Fabrication	on-site
Cracks	none (no reentrant corners either)
Joint problems	minor
Moisture problems	minor
Impact damage	none

Building construction and EIFS retrofit was similar to that of side walls on Building 12. It was reported that in some areas the surface appeared to be delaminated on warm days, under the right lighting conditions. The effect was not visible during the period of observation, and no delamination was located by tapping the surface in the suspect areas.

BUILDING 14 Hotel

Location	Toronto
EIFS height	7 storeys
Interior humidity	low
Age of structure	2 years
Age of EIFS	2 years
Insulation thickness	approx 50 mm
Substrata	concrete and gypsum board
Fastening	adhesive
EIFS drawings	unknown
Fabrication	site applied
Cracks	minor
Joint problems	none
Moisture problems	none reported
Impact damage	minor

The project was intricately detailed to look like an 19th century Austrian palace. Two large panels, not finished at the same time as the others, contrasted in color and texture with the panels they should have matched. The building manager reported no problems and few cracks were observed. Some impact damage had occurred at upper levels.

BUILDING 15 Hotel

Location	Toronto
EIFS height	6 - 8 storeys
Interior humidity	low
Age of structure	5 years
Age of EIFS	5 years
Insulation thickness	approx 50 mm
Substrata	gypsum board, concrete
Fastening	adhesive
EIFS drawings	unknown
Fabrication	panellized, except on concrete
Cracks	minor
Joint problems	moderate
Moisture problems	minor
Impact damage	minor
Sample location	impact damaged area, shaded, South-facing
Lamina weight	6.0 kg/m²
Polymer content	12.6%
Water absorption	7.9%
Base coat thickness	2.5 - 3.2 mm
Finish coat thickness	0.1 - 1.5 mm
Reinforcement	1 layer @ 0.14 kg/m² + 1 layer @ 0.59 kg/m²

At grade, the front and parts of the sides of the building, including arcades and entrances, were precast concrete, detailed to simulate stone. Sides, back, and upper floors were clad with an EIFS, also detailed to look like stone. On the rear elevation the parapet was EIFS clad and had been damaged by swing stage outriggers. The building was very dirty and stained. Where flow of water was concentrated, the dirt was also concentrated in streaks. This was especially noticeable on the undersides of the belt courses, which did not have drips. On the front elevation 8 out of 20 reentrant corners (at tops of windows) were cracked. On the rear elevation, where the windows were detailed differently, only about three out of 20 corners were cracked. Sealant failures seemed fairly numerous. They were typical failures of adhesion between finish coat and base coat. Expressed as a percentage of total contact surface area they probably would not exceed 5%. Cracking of the cornices and belt courses was common. On the front elevation, the cornice seemed to have joints at every second bay which were not caulked, but perhaps coated over. The surface was discolored at the joint location over a width equal to one of the soft joints, but the surface texture was the finish coat texture. Most of these joints were cracked. They were presumably joints between prefabricated sections which were initially indistinguishable from the rest of the cornice. On the rear the cracks in the belt courses were at irregular intervals, without the uniform stripe of discoloration seen on the front cornice. Unlike the front cornice, there were soft joints. The cracks occurred at roughly equal intervals, at a frequency varying from two to three per length between soft joints.

BUILDING 16 Low Rise Residential

Location	Toronto
EIFS height	7 storeys
Interior humidity	moderate
Age of structure	3 years
Age of EIFS	3 years
EIFS type	polymer modified (5 mm thick)
Insulation thickness	75 mm
Substrata	portland cement board sheathing on steel studs
Fastening	mechanical
EIFS drawings	architectural (with very little detail)
Fabrication	panellized & on-site
Cracks	moderate
Joint problems	moderate
Moisture problems	minor
Impact damage	minor

Cracks at the outside corners adjacent to larger panels of site applied EIFS were common. They tended to align with the back of the insulation on one side or the other of the corner. As a hypothesis, it seems likely that metal stud wall deflection, together with relatively brittle base coat and strong insulation may have combined to cause these cracks. One panel had extensive, apparently random cracking. In other cases cracks echoed the locations of insulation joints. Soft joints were in good condition generally. The stud cavities were filled with batt insulation. Some caulking was missing between panels. There was no evidence of moisture related damage, and none was reported by the building manager.

BUILDING 17 Restaurant

Location	Vancouver
EIFS height	2 storeys
Interior humidity	moderate
Age of structure	approx 4 years
Age of EIFS	approx 4 years
Insulation thickness	unknown
Substrata	unknown
Fastening	adhesive
EIFS drawings	unknown
Fabrication	on-site
Cracks	none visible
Joint problems	none
Moisture problems	not evident from outside
Impact damage	minor

A small building clad with an EIFS. The building had experienced typical impact damage on the lower level. A large sloped section of EIFS roof, one storey in height, was constructed with a 2-part polyurethane waterproofing between the base coat and the finish coat (based on information from the supplier). There was no visible evidence of deterioration or cracking.

BUILDING 18 Low Rise Residential

Location	Toronto
EIFS height	3 storeys
Interior humidity	moderate
Age of structure	approx 30 years
Age of EIFS	approx 5 years
EIFS type	not an EIFS; acrylic finish coat over portland cement plaster on metal lath
Insulation thickness	150 mm
Substrata	clay brick
Fastening	mechanical
EIFS drawings	unknown
Fabrication	on-site
Cracks	moderate
Joint problems	no soft joints
Moisture problems	minor
Impact damage	minor

The building was finished with conventional portland cement plaster over about 150 mm of beadboard, with an acrylic finish coat. The plaster was reinforced with expanded metal lath mechanically fastened to the brick. The supplier of the materials indicated that the base coat as well was acrylic modified, although it was applied over wire mesh, with expanded metal beads and corners. Around power service entrances, gas meters, and similar existing appurtenances, the retrofit was omitted, without any finish on the exposed edge of the foam. In a few locations the acrylic finish was delaminating, especially where it was near grade and subjected to splashing water. One spot was observed where the finish was peeling without any obvious source of moisture. Where it was exposed, the metal lath was rusting. Conventional stucco control joints were located midway between windows. There were cracks at many of the reentrant corners of the punched window openings.

BUILDING 19 Mixed Use Retail/Residential

Location	Toronto
EIFS height	10 storeys
Interior humidity	moderate to high
Age of structure	3 years
Age of EIFS	3 years
Insulation thickness	150 mm
Substrata	concrete and gypsum board
Fastening	adhesive
EIFS drawings	unknown
Fabrication	panellized & on-site
Cracks	moderate
Joint problems	minor
Moisture problems	minor
Impact damage	minor

This building was a combined residential-retail complex. Two walls of the upper floors were enclosed with EIFS panels with long horizontal strip windows, while the other walls appeared to be finished with a site-applied EIFS on concrete. Five out of 20 reentrant corners had cracked.

Sealant appeared to be in good shape. One wall was finished with an EIFS in an unusual way. Panels of insulation about 1.5 m square and 150 mm thick were prefinished with a sand-textured EIFS, including edge-wrapping, and were then installed like tiles by adhesion to gypsum sheathing, with soft joints between tiles. Thickness and joint size tolerances appeared not to have been well controlled. Louvers were cut into the EIFS, with edges of insulation and sheathing left open to the elements.

BUILDING 20 Mixed Use, Retail/Office

Location	Vancouver
EIFS height	12 storeys
Interior humidity	low to moderate
Age of structure	approx 3 years
Age of EIFS	approx 3 years
Insulation thickness	unknown
Substrata	unknown
Fastening	unknown
EIFS drawings	unknown
Fabrication	on-site
Cracks	minor
Joint problems	minor
Moisture problems	unknown
Impact damage	minor

Upper floors were primarily curtainwall with limited EIFS, while lower floors were EIFS with punched windows. Crack patterns were visible above windows at edge of the EIFS, possibly due to movement of an edge molding. Damage due to frequent changing of signs attached to the EIFS surface was extensive (both tenant signage and realtor's temporary signage contributed).

BUILDING 21 Shopping Centre

Location	Vancouver
EIFS height	5 storeys
Interior humidity	low
Age of structure	approx 5 years
Age of EIFS	approx 5 years
Insulation thickness	50 mm
Substrata	gypsum board
Fastening	adhesive
EIFS drawings	unknown
Fabrication	on-site
Joint problems	major
Cracks	minor
Moisture problems	major
Impact damage	minor

EIFS cladding was divided into large rectangular panel sections. Two large sections of EIFS had delaminated from the wall. The walls were inspected shortly after the failure and again subsequent to the repairs. Based on observations from ground level and the limited information available, the following factors are surmised to have contributed to the failure. Soft joints were spaced approximately 7 m horizontally and 3 m vertically. The finish coat failed in several locations where sealant pulled it away in soft joints. Some joints appeared to have experienced excessive movement. Rain water penetration into failed soft joints loosened the bond of the EIFS to the gypsum board. Large sections of the EIFS fell to the ground. The wall was reclad with mechanically-fastened EIFS over a membrane air-seal.

BUILDING 22 Mixed Use, Retail/Office

Location	Vancouver
EIFS height	7 storeys
Interior humidity	low
Age of structure	4 years
Age of EIFS	4 years
Insulation thickness	38 mm
Substrata	gypsum board
Fastening	adhesive
EIFS drawings	architectural
Fabrication	on-site
Joint problems	minor
Cracks	minor
Moisture problems	minor
Impact damage	minor
Sample location	North-facing back of parapet, frequently wetted by concentrated drainage (below joint in parapet cap flashing)
Lamina weight	2.7 kg/m²
Polymer content	14.6%
Water absorption	8.8%
Base coat thickness	0.5 - 0.75 mm
Finish coat thickness	0.1 - 0.75 mm
Reinforcement	0.12 kg/m²

The building was detailed with three colors of EIFS cladding, mixed with precast concrete and masonry. Lower levels exposed to pedestrian traffic were clad in masonry. Most upper windows had steeply sloped EIFS sills, which displayed minimal deterioration. Few cracks were observed. Foil-faced gypsum board, with foil to the interior, was utilized as the support. Horizontal flashings were installed at floor levels, extending through the insulation. The lamina was tight to upper flashing surface, while the underside was caulked. The flashings were likely ineffective in removing moisture; however, some seepage was noted. Caulking was well applied and in good condition. Mold and moss were visible on the EIFS surface in several areas. One area had hexagonal pattern cracking in the finish coat. The finish appeared to have shrunk and cracked before fully curing, possibly as a result of freezing. Through the removal of a sample in an area which appeared to be in good condition, a section which was not bonded to the support was inadvertently discovered, which appeared not to have been adequately pressed into place during construction.

BUILDING 23 Office Building

Location	Vancouver
EIFS height	14 storeys
Interior humidity	low to moderate
Age of structure	approx. 25 years
Age of EIFS	4 years
Insulation thickness	38 mm
Substrata	primarily gypsum board
Fastening	mechanical
EIFS drawings	retrofit architectural
Fabrication	on-site
Cracks	none observed
Joint problems	minor
Moisture problems	none evident
Impact damage	none (all well out of reach)

The building was originally clad with glass mosaic tiles bonded to concrete. Due to delamination of the tiles, the building was reclad with an EIFS. The tiled surface was wrapped with wire mesh and clad with metal strapping and gypsum board. The metal strapping space was vented to the exterior with louvers at mid height and lower edge of wall. Window perimeters were stepped back, with EIFS insulation attached directly to the wall around each window perimeter. The two larger building faces were each bisected by one vertical soft joint, with approximately 30 m from joint to corner. A short section of one joint had failed. Other than this, there were no soft joints. There were no visible cracks, despite the large number of punched windows. The insulation was mechanically fastened to the gypsum board through a layer of spunbonded polyolefin building paper.

SUMMARY & DISCUSSION

Joints & Junctures

Often problems occur with interfaces to other materials, particularly windows, rather than in the EIFS or at joints between panels of EIFS cladding.

There was relatively little failure of soft joints, as a percentage of total joint length observed. Nevertheless, significant water damage from failed joints was observed on six buildings. Some failures seen were clearly EIFS-related. The most common soft joint failure was at building expansion joints, where there had been movement between the supporting structures. Where one EIFS panel meets another at a soft joint, if both are mounted on a common continuous substratum it appears that there is typically relatively little movement. Sealant failures included tears due to sealant applied too thin, uncured sealant, and other defects which are not unique to joints in EIFS.

In addition to these problems common to all sealant joints, there were failures caused by delamination from the base coat of the EIFS finish coat in the joint. These latter failures were commonly associated with moisture in the joint. This mode of failure is commonly reported for EIFS joints. The finish coat is porous and will hold water. The polymers in the finish often soften on extended exposure to moisture. The layer of finish coat on the side of the joint, between the sealant and the base coat, cannot dry as easily as it could if exposed to the air. In addition, chemicals in the sealant may soften the finish coat. Once it softens, very small tensile stresses in the sealant will cause the finish to debond from the base coat.

Some manufacturers currently recommend keeping the finish coat off surfaces to which sealant will be bonded. No cases where efforts appeared to have been made to omit the finish coat from the sides of the joints to allow sealant to be adhered directly to the base coat were observed.

Because EIFS systems are face-sealed and made of materials susceptible to water damage, defective joints are more serious than they are with many other cladding materials. On some of the buildings examined, the caulking at perimeters and in soft joints was poorly installed. The joints were not correctly sized, sealant depth to width ratios were not correct, backer rod was often not installed, and tooling of the sealant was not correctly completed. The use of qualified tradesmen to install the sealant is recommended.

Two panellized buildings were observed which had two stage joints, with beads of sealant at the back of the edge wrap and at the face of the joint.

Cracks

Surface articulations, corners of openings, and gaps or steps in the insulation surface all concentrate stress in the lamina, and often cause cracking. Moisture in the insulation will cause cracks which would not otherwise occur. Cracks are more likely when the base coat is very thin, and at edges of laps in the reinforcing mesh. Observed cracks could be attributed to each of these causes. The literature reports that EIFS insulation shrinks for a time after manufacture; if it is not cured adequately before use, this may cause cracking at insulation joints. There was no evidence to attribute any of the observed cracking to this cause.

There was some indication that cracking may increase with thicker insulation. In one case (Building 10) extensive cracking was associated with lack of polymer coating on the reinforcing mesh, suggesting that mesh weakened by alkali attack may have been a factor.

Corner cracks were frequently observed at punched windows. Manufacturers recommend diagonal reinforcement of opening corners, in conjunction with placing insulation joints away from corners. It was not possible to tell if this had been done on the buildings examined, but others have reported that this procedure is often ignored. Cracks at inside corners of openings in the system were very common. The recommended joint location and reinforcement procedures may solve this problem if applied consistently.

Cracking often occurs at insulation board joints, particularly where open joints have been partly filled with base coat. Cracking was commonly associated with moisture in the insulation, often without any other evident factor to explain it. Two types of moisture related cracks were observed: numerous closely spaced cracks, typically centered on strands in the reinforcement mesh; and isolated cracks with efflorescence. In several instances short cracks (75 - 300 mm long), where efflorescence indicated evaporation of moisture from inside the system had occurred, were observed. These cracks were not associated with any obvious stress concentration site. It appears that moisture trapped behind the lamina will freeze during cold temperatures, cracking the lamina.

The panellized buildings had more frequent soft joints and fewer punched openings than the site-applied buildings; cracking was less common. Thin insulation and solid supporting surfaces (masonry or concrete) seemed to be associated with large uncracked surfaces.

The EIFS is obviously quite unlike precast concrete and other similar materials for which one designs joints based on unrestrained thermal behavior. Were it not for the restraint of the insulation, the EIFS could not perform as well it does. This point is widely misunderstood. Most cracks in EIFS lamina are probably due to thermal movement; but the cause is failure of the insulation and lamina to prevent movement, not failure of joints to allow it. If the lamina were to move freely in response to temperature change, it would either delaminate from the insulation, or pull the insulation off the support, curling the EIFS like a bimetallic strip. In one case (on Building 10) there was a crack where the lamina did appear to have curled the insulation in this manner, pulling it away from the supporting wall for a distance of perhaps half a metre on each side of the crack.

In mechanically fastened systems, the fasteners are reported to contribute to cracks due to concentrated loads. None of this type of cracking wass seen in the small sample of mechanically fastened systems observed.

All buildings had some crack problems to varying degrees.

Impact Resistance

Although the material looks like concrete, stone, or stucco, it has low resistance to impact. There was extensive damage at loading docks and on recreation facilities. On two recreation facilities, vandals had discovered that stones thrown at the surface punch holes in the lamina and embed in the insulation. Where cars or shopping carts and EIFS cladding were in close proximity there was damage in every case. Some of the damaged areas had been reinforced with high impact mesh. The heavy mesh does provide additional resistance, but appears not to be adequate for loading docks or vehicular areas, nor would it appear to be adequate for areas subject to vandalism.

Areas near grade are not the only places where damage can occur, there were instances of damage caused by swing stages used for washing windows, and one case of damage from objects thrown from higher adjacent buildings.

Undamaged areas which were reinforced with heavy mesh were no different in appearance from areas without the extra layer of mesh. Impact damage was not observed to have caused crack propagation.

Application Tolerances

The EIFS lamina is very thin. The difference between too thick and too thin is on the order of a millimetre. If the mesh is not fully covered front and back, the lamina will not be waterproof. The natural tendency when applying the material with a trowel is to use the face of the mesh as a screed, resulting in too thin a coating. To apply a coating of uniform thickness over the mesh is difficult, particularly if the mesh is being embedded and coated in one operation. A cost conscious applicator may be tempted to neglect measures necessary to ensure adequate thickness.

In several instances the texture of the reinforcing mesh could be seen in the finished surface. In at least one of these cases, the thin lamina appeared to have allowed water to enter the insulation and collect in soft joints behind the sealant.

Surface Wetting

Some failures, including delamination of the finish coat in soft joints, can be precipitated by wetting of the finish coat. There were instances where surface wetting had eroded or caused delamination of the finish coat, and one instance (Building 4A) where the finish coat had been pulled off by accumulated ice adhered to the surface. There were also instances in the field where the insulation behind the lamina, and the backing rod behind the sealant, were saturated with water. There were several instances of finish coat deterioration where snow had rested against walls.

Moisture Penetration

Water causes deterioration of the EIFS, once it gets into the system from flashings above, from window openings, through cracks, through failed joints, from water spilled on the interior, or through the face of the lamina.

Small cracks were observed which showed signs of weeping and evaporation, sometimes with stains caused by solutes picked up before the water entered the EIFS (green stains from copper flashings, for instance). There were cases where water was trapped, soaking the lamina from the back and softening the finish coat, and promoting deterioration of the supporting structure. In some cases water had accumulated behind foam rod and sealant in joints which appeared to be in good condition from the exterior (the water appeared to have passed through the lamina from the face of the wall).

In one case water had entered an unfinished soft joint (where sealant had been omitted for a short distance), travelled through the insulation, and leaked into the interior at a location several metres away, causing extensive drywall and carpet damage.

In three of the buildings examined, significant portions of the EIFS had been damaged by water and replaced. Leakage of water through joints and junctures, as well as from interior spills, appeared to have caused more damage than condensation.

Condensation

If the material supporting the insulation is one which can be damaged by moisture, the EIFS insulation thickness should be enough to ensure that the dew point for interior air occurs within the EIFS insulation for the worst winter conditions. This is most easily achieved if there is no other insulation, and when the interior Relative Humidity is low. If there is other insulation in the wall, an unreasonable thickness of EIFS may be required.

If the dew point is within the supporting wall, even when the EIFS substratum and supporting construction can withstand the resulting condensation, the EIFS is subjected to more severe freezing and thermal stress. Insulated spaces behind an EIFS may also serve to trap water which, having entered, is unable to escape by evaporation because of vapor impermeable materials on both sides (the EIFS, an air seal membrane if used, interior polyethylene film, or just impermeable interior finishes).

Substrata

When gypsum board sheathing is used without an air seal membrane, water in the system will cause the paper to lose it's bond to the gypsum, and the gypsum itself will swell and weaken, particularly if there is batt insulation behind it. The EIFS is then no longer bonded to a solid mass, but to a wet paper face. The authors do not recommend gypsum board as an EIFS substratum unless it is protected from leakage, condensation, and interior flooding. Various materials are available which are less susceptible to moisture damage, although other properties; brittleness, screw holding, cost, and combustibility in particular; need to be considered. Portland cement board has been utilized as an alternative. The material itself is less susceptible to moisture damage. However, it is heavy, subject to localized crushing damage, screws punch through it readily and it is more costly. While the board may be more resistant to water damage, the fasteners and supports remain susceptible.

Attachment

Nearly all of the EIFS observed was adhesive-attached. Typically, adhesive was applied by the intermittent dab method and covered less than half of the area sampled. In addition to keeping the EIFS attached to the building, adhesive probably plays a role in preventing cracks. The small, and relatively few, samples taken provide a poor estimate of the extent of poor adhesion, but suggest that typical workmanship may often fail to ensure uniform and continuous adhesive attachment.

Since a face seal system must be 100% air tight to prevent water infiltration, it must carry 100% of the wind load. Some existing applications may be able to do this from day to day, but not when the full design wind occurs. Sufficiency of current methods of fastening gypsum board for anticipated design wind loads has been questioned.[6]

Limited sections were observed where the EIFS had delaminated. As seen from the Building 22 sample, sections that are not adequately bonded are not always apparent from the exterior. It must be assumed that there were sections which were not adequately adhered in many of the buildings examined. In the absence of a non-destructive method of identifying sections where the insulation is not attached, it is possible that some claddings which appeared to be in good condition externally may need only a good windstorm to detach them.

The bond and performance of EIFS when installed over backup materials other than concrete and masonry requires further investigation.

Application of finish coat directly to concrete results in delamination after a short service life.

Movement of Supports

Transitions or movement in the supporting backup often cause cracking if joints in the EIFS are not provided. If the EIFS bridges between supporting surfaces which move relative to each other, cracks are particularly likely. However, soft joints were observed to fail more frequently at such locations than elsewhere. In one case where cracking was extensive, the largest cracks were located at transitions between cast-in-place concrete and concrete masonry supports, where the EIFS was applied continuously. At the same time, EIFS systems appear to be capable of accommodating limited movement between adjoining substrata.

6. McDonald, D. & Quirouette, R., *Structural Requirements for Air Barriers*, CMHC Report No. 30133.OR1, 1991.

Lateral movement of supports, and deflection due to lateral loads, may also cause cracking in some cases. With one polymer modified system, cracks were observed near the floor lines and at outside corners which were consistent with failure to accommodate normal movement in the steel stud backup. Such cracks were not observed in seemingly similar polymer based installations.

Mix Proportioning

There are several components in the mixing and installation of EIFS that may affect the performance. The mix proportions of the lamina materials can be significantly different between manufacturers and product lines. Installer's interpretations of a workable and cost effective mix can vary. Most products require the site addition of water, while some require portland cement and occasionally sand be added to the mix. There can be a cost saving in the altering of these proportions. Undermixing may result in inconsistent materials, while overmixing may result in air entrapment and product damage. Performance properties such as flexibility, workability, color, texture, water absorption, water erosion resistance, vapor permeance and durability, may all be affected by the formulation, mixing and curing of the EIFS.

Color Uniformity

Applicators sometimes have difficulty getting the material to match, even with premixed materials. On at least three buildings, there were adjacent panels which had visible unintentional differences in colour and texture of the original finish.

Some colors of pigment, particularly darker colors, are more susceptible to photo-degradation than others. One building examined showed pronounced fading of darker colors on South-facing elevations compared to other elevations, while lighter colours showed no visible difference.

Repair & Cleaning

Like most finishes, an EIFS is difficult to repair to match the original texture and color. However, the EIFS is more readily damaged. Furthermore, if repairs are not done promptly and moisture gets into the system, damage can be extensive. Both color and texture are hard to match, even when the patching is done with the original materials. Several instances were seen where attempts had been made to patch with conventional stucco or mortar materials. These patches were even less successful than those made with EIFS materials.

Impact damage is not the only cause of need for repairs. There were several instances where rearrangement or replacement of signs and fixtures had left unsightly blemishes. Buildings with retail rental space showed this more than most, because of frequent sign changes, but even small *no parking* signs are difficult to mount unless independent supports are provided.

Recaulking of joints and cleaning also present unusual difficulties. Grinders, pressure washers, solvents, sandblasting, and most power tools are all inappropriate. This makes premature dirt accumulation and joint failure more serious than they would be with other materials. There does not appear to be an effective means of recaulking soft joints.

Moss

Several sections of EIFS were supporting growths of moss and possibly other organisms. Such growths might be considered attractive in some cases, but probably tend to retain moisture and retard evaporation. They may thus shorten the life of the finish coat, even if no need is felt to remove them from an appearance standpoint.

Recent Innovations

EIFS manufacturers have recently introduced alternatives to the conventional systems which address combustibility and incorporate rain screen concepts. These systems are in the infant stages, having yet to be fully tested onsite. Durability and weather resistance may prove less than expected.

RECOMMENDATIONS

Future Research

Strength of Reinforcement

The literature states that alkali attack on the surface of glass fibres will lead to dramatic loss of strength. There were examples of extensive cracking in the field (e.g. Building 10) which could be due to this effect. Tensile testing of mesh samples before and after accelerated exposure to alkali might reveal the extent to which this is a danger. Are all fabrics susceptible to more or less the same degree, or is there variation from batch to batch, from one spot on a roll to another, or between manufacturers? Does the polymer in the base coat protect the fibres in the mesh? Answers to these questions would suggest remedies. It might be appropriate to limit free lime levels in the base coat if all glass is equally susceptible. Alternatively, if glass is highly variable, then perhaps specifications should stipulate maximum strength loss values for the mesh, in relation to a standard test, and samples should be taken from the jobsite and tested. If the base coat polymer provides adequate protection, the whole issue may be moot.

Suggested Research: Perform tensile strength tests on several samples of reinforcement from several manufacturers. Evaluate methods of identifying mesh protection from alkali attack. Test for strength before and after accelerated exposure to alkali, both for bare mesh and mesh coated with cured EIFS base coat.

Water Penetration

Tests in the US have revealed that the EIFS lamina can be quite water permeable. Clearly trowel applications tend to result in applications thin enough to fail as a barrier to water. There were several cases where the texture of the mesh was visible in the finish coat. Is this something which depends only on the good will and skill of the applicator, or do different methods of application (1, 2 or 3 passes for instance) carry significantly different risks of the base coat being applied too thin?

Suggested Research: Evaluate the moisture permeability of the lamina when subjected to humidity, moisture spray and constant water head, for variable base coat thickness and application method (trowel, spray and 1, 2 or 3 coats). In addition, evaluate the drying characteristics through the lamina of saturated insulation.

Joint Location

There was enough cracking, coupled with relatively little cracking on panellized buildings, to suggest that joints are needed at intervals and that punched openings should be avoided. At what intervals should joints be located? Although ambitious, a combined laboratory/theoretical investigation might be able to illuminate this question. What are the critical properties? Elasticity of the lamina? (Probably not, since glass mesh is used.) Elasticity of the insulation? Shear strength of the lamina to insulation bond? Cohesive strength of the insulation? Bond strength of insulation to support? Thermal coefficients of expansion? Thickness of insulation? If the properties of the materials and thickness of the system are known, can maximum joint spacing be predicted?

Cracks at inside corners of openings in the system have been common. Are the recommended insulation joint location and reinforcement procedures (which may often be ignored) enough to prevent cracking, or should punched openings be avoided altogether? Does size of opening influence this?

Suggested Research: Evaluate the drying shrinkage and thermal coefficient of expansion of the unrestrained surface lamina, limits on the ability of the bond to the insulation to restrain such movements, and effects of insulation thickness on thermal movement of the surface of the composite. Test reinforcement of reentrant corners.

Sealant Failures

Are elastomeric sealants feasible for EIFS joints? Apart from the difficulty of keeping the finish coat out of the joint without revealing a contrasting strip of base coat between the edge of the finish and the sealant bead, are there sealants which are elastic enough to reliably fail cohesively, and which can be repaired with the same material? Solvent attack and strength in excess of that of the EIFS components remain concerns. Unless sealants, when they do fail, can be cut out of the joint with a knife, leaving a reliably attached residue of cured sealant on the EIFS surface to which new sealant can be bonded, then joints in EIFS which rely on sealant cannot be repaired by installing new sealant in the original joints. Pressure equalized two stage joints are an obvious possible solution to the joint problem, using something other than caulking for the exposed seal.

Suggested Research:

- Review literature and interview sealant manufacturers to determine appropriate low modulus sealants, with consideration to the long term effects of solvents and plasticizers in the sealant on the base coat, reinforcement and insulation. Test promising sealants to determine how to ensure cohesive failure without damage to the EIFS. Expose some test samples to moisture. Test rebonding of new material to cured sealant.
- Devise and evaluate alternate joint designs using two stage joints, with baffles in place of sealant for the outer stage, with pressure equalized joint design. Look for rain penetration, drainage, and thermal performance.

Future Applications

The following points summarize recommendations for application of EIFS to future projects.

- Mandate architectural technical input. Provide shop drawings indicating joint details, joint spacing and junctures. Have inspections completed by qualified and experienced third parties on all significant projects.
- Don't use EIFS in high impact areas or on stud framing with gypsum sheathing where a physically secure wall is required. Use more impact resistant material such as concrete, masonry or stone, particularly at loading docks, parking spaces, and roadways.
- Use windows which can be cleaned from the interior, except where they are accessible from the ground or balconies without ladders or staging.
- Design the cladding, and all attachments, to withstand the full wind load.
- Use gypsum-based boards as substrata only when air sealed and waterproofed with a membrane on the outside. Otherwise, consider a more moisture resistant sheathing containing no gypsum; exterior and water resistant gypsum boards are not sufficient.
- Install additional insulation in the stud spaces of frame walls supporting EIFS only after thermal profiles have been considered for the winter design condition.
- Remember that dark colours fade and deteriorate more rapidly, and that they subject the surface to more extreme temperatures, both in sunlight and on clear nights.
- Avoid punched openings by detailing joints in line with reentrant corners.
- Use two stage (rain screen) joints. Use something other than caulking for the outer seal, where possible. Don't install the finish coat into joints to be caulked.
- If sealant is used, use low modulus sealant with controlled minimum cross sections. Use a brand of sealant known to be compatible with the particular brand of EIFS. Take greater care than for sealant installations in other materials.
- Use building expansion joints which do not depend on adhesion of sealant to EIFS. Terminate the EIFS by sealing it to a part of the joint assembly which is attached to the same continuous substratum.
- Provide mounting for signs and other such fixtures, independent of the EIFS.
- Secure EIFS to rigid substrata such as concrete or masonry where possible. If flexible supports are used, evaluate potential movement at connections and junctures between different parts.
- Don't use EIFS cladding as a window sill or roof parapet flashing.
- Ensure that drainage from other surfaces does not flow over the EIFS finish, and that icicles will not form on it.
- Do not use EIFS where snow will be rest against it for extended periods of time.
- Provide drips on undersides of projecting EIFS elements.
- Cure EIFS materials a minimum of 24 hours at temperatures above 5 °C.
- Promptly repair damage to the EIFS to prevent ingress of moisture.