

DESIGN & RENOVATION OF A HIGH-RISE RETROFIT EIFS CLADDING

A C A S E S T U D Y

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History and Background

A high-rise, low-income apartment project located in Minneapolis, Minnesota, was originally constructed in the 1970s with site-fabricated, concrete spandrel panels and column covers. Due to structural concerns, extensive panel cracking, and significant water leakage problems, the building was retrofitted in 1984 with a cladding system composed of polymer-modified (PM) Exterior Insulation and Finish System (EIFS). Within a few years, noticeable cracks had developed throughout the retrofit cladding system, and significant changes in the appearance of the EIFS became manifest. Extensive investigation and analysis revealed specific material defects that were particular to the mid-western EIFS manufacturer (no longer in business), as well as poor detailing during the design process and improper workmanship related to several key aspects of the building envelope. The EIFS wall cladding suffered progressive deterioration until early 1993, when a severe wind storm removed a section of the cladding from an upper floor at one end of the building.

The owner and manager of the property, a non-profit organization dedicated to community redevelopment and neighborhood preservation, commissioned a comprehensive inspection of the EIFS cladding on the entire building. The investigation included visual inspections by a number of different parties, field leak testing, and *in-situ* testing of the structural integrity of the EIFS assembly using a pull test method originally developed by this author.¹

Upon completion of the investigations, it was determined that the EIFS cladding system, after only ten years, had experienced widespread failure, was unsalvageable, and would have to be replaced. Litigation related to the cladding failure resulted in a settlement that allowed the building owner to initiate steps to successfully remove and replace the EIFS cladding. These steps included development of comprehensive construction documents, prequalification of bidders, competitive bidding, close project management and contract administration by the design professional, and full-time, third-party inspections of the installation. Due to the involvement of financial assistance from the

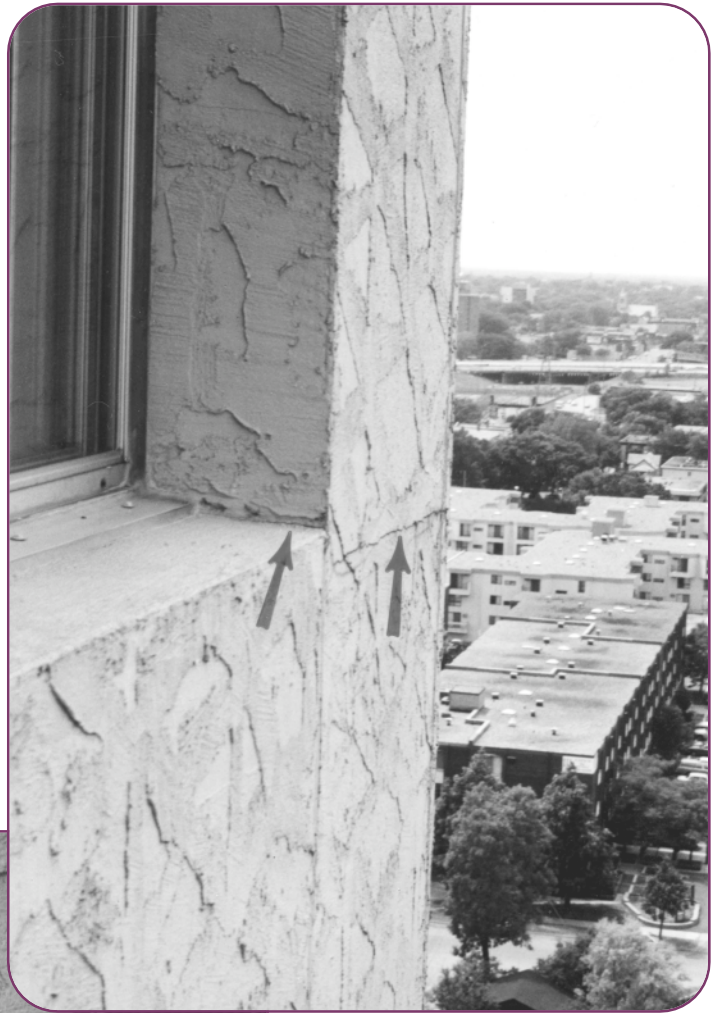
Department of Commerce, Housing and Urban Development (HUD), all of the project administration procedures were required to comply with regulations of that agency.

A number of conditions found at this project were attributable directly to poor workmanship during the original installation of EIFS materials and could be summarized as follows:

- Poorly finished EIFS edges and corners.
- Inadequate key-in of EIFS materials at edges of control joints and other metal accessories.
- Improper "mitering" of control joint corners.
- Inadequate applications of EIFS material finishes with respect to material thickness in some locations, as well as at corners.
- Incomplete applications of EIFS material finishes with respect to edges and corners.
- Improper termination of control joints at window recesses.
- Securement of insulation board and mesh to substrates using fasteners with spacing and patterns that exceeded 2 square feet per fastener.
- Glass fiber mesh that ran continuously behind control joints.
- Mortar bridges within bellows of control joints due to EIFS materials "slop."
- Omission of control joints at specified locations.
- Substitution of differing control joint materials, including zinc, galvanized steel, and PVC.
- Texture coat and acrylic color coat applied directly to scratch coat of EIFS material.
- Improper surface preparation prior to installation of building sealants.
- Omission of backer rod at sealant installations in some locations.

Based upon our observations, it also appeared that certain constituent materials utilized during the retrofit installation of PM EIFS cladding at this project may have been defective.

- Sealants installed within the building joints and at window perimeters exhibited extreme conditions of “reversion,” which have resulted in adhesive and cohesive failures, as well as lack of movement capability and dirt retention.
- Glass fiber mesh utilized within the PM EIFS lamina throughout the building had experienced embrittlement and loss of tensile strength, indicative of improper or inadequate application of protective coatings on the mesh, as well as advanced alkali attack of the glass fibers.
- Splitting of the metal control joints was a serious and widespread problem that may be due to manufacturing defects or stress fatigue within the metal alloys used for these building components.



Above. Figure 1—Inadequate slope at original sill.

DESCRIPTION OF PROJECT

General

The subject property is a cast-in-place, reinforced, concrete-framed structure. This twenty-one story building consists of two adjacent wings that have rectangular-shaped floor plans or footprints. The two wings have central axes that run parallel to each other, but were offset a certain distance laterally. This offset results in half-width end walls at each wing occurring at approximately the midpoint of the total building length, such that the East Wing has a west, half-width endwall and the West Wing has an east, half-width endwall.

Main entrances occur along the North and South elevations at the offset. The endwalls at all locations feature a vertical recess running the full height of the building. At the East Wing, east endwall, and the West Wing, west endwall, the notch occurs at the building centerline and corresponds to the stairwells at each end. At the half-width endwalls, the notch occurs adjacent to the continuation of the offset building wing. See Figure 8.



Left. Figure 2—Typical sill and A/C opening.

EXTERIOR WALL CLADDINGS

1970s Original

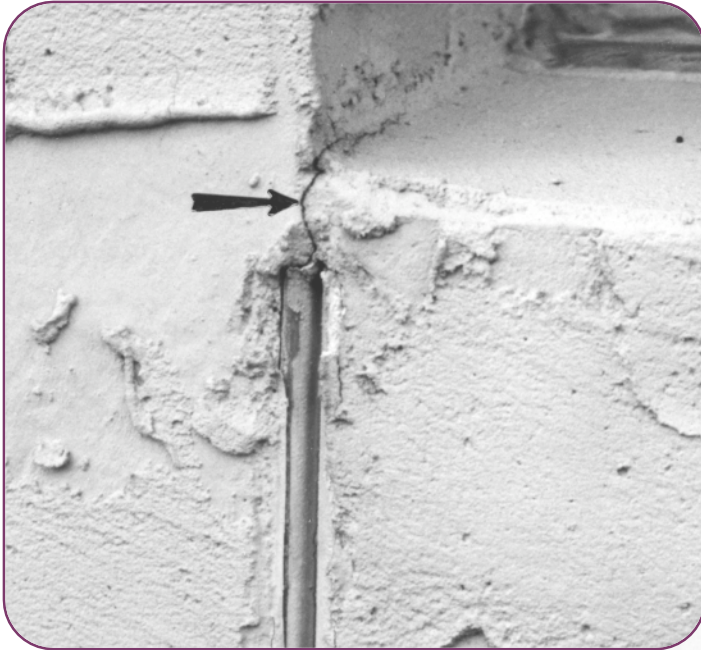
The original exterior wall cladding at this project, dating from about 1974, was comprised of site-fabricated concrete spandrel panels and column covers that were reportedly “shot-creted” in place using an innovative application procedure.

Details and historical records were incomplete, but it is reported that interior water leakage was experienced virtually from the beginning of the project. Ultimate investigation and analysis of the problems revealed significant strength deficiencies of the concrete materials comprising shot-crete spandrels, which resulted in severe cracking and the water infiltration. Since there was little confidence in the strength and security of the original shot-crete spandrels, it was decided in 1984 that the renovation cladding system would be supported on a steel stud framing system that

spanned from exposed floor slab to floor slab, with angle brackets installed at every stud for each floor level. This framing system was designed and installed at the north and south elevations prior to installation of the retrofit PM EIFS cladding.

1984 Retrofit EIFS

The retrofit building envelope was comprised of EIFS spandrel panels and column covers with aluminum and glass punched windows regularly interspersed on the North and South elevations. The East and West endwalls are "solid" walls that are only



Above: Figure 3—Control joint termination.

Right: Figure 4—Prefabricated sill.

broken up by control and expansion joints. Both wall assemblies utilized a polymer-modified (PM) EIFS as the primary cladding material, using mechanically-fastened, extruded, expanded polystyrene (XEPS) insulation board.

At the north and south elevations, the insulation and reinforcing mesh were fastened over a gypsum sheathing which was attached to metal studs using a screw fastener with one-inch diameter washers. At the end walls, the insulation and reinforcing mesh were fastened directly to concrete shear wall panels using a hand-driven concrete pin, set in pre-drilled holes. The concrete pins also had been provided with one-inch diameter washers. In both assemblies, the insulation board was covered with an acrylic-modified cementitious base coat that was reinforced with a glass fiber mesh.

The wall assemblies at this project have received a final application of a textured coat applied in a web pattern. During inspection, we found the texture coat to vary in texture as well as in composition. The texture coats at the West Wing, west end-wall were comprised of a lean mixture and easily disbonded from the underlying PM EIFS, while texture coats at the East Wing, east endwall were comprised of a rich Portland-lime mixture that

was well-bonded to the underlying PM EIFS. Texture coats on the North and South elevations ranged between these two extremes.

The entire system was finally coated with a waterproofing layer consisting of an acrylic, elastomeric coating. Total specified thickness of the entire synthetic stucco system, or "lamina" was approximately 3.2 to 4.8 mm.; however, we found that the actual installation varied considerably from these norms.

Primary advantages of EIFS-type cladding systems are exceptional thermal efficiency of the assembly, attractive finish color and texture, and economical initial cost of construction. However, there have been a number of problems identified with these systems, including inadequate design and detailing, lack of proper workmanship, cracking, and extensive deterioration of substrate materials when subjected to chronic and long-term building leakage, etc.²

Problems Observed in Previous EIFS Installation

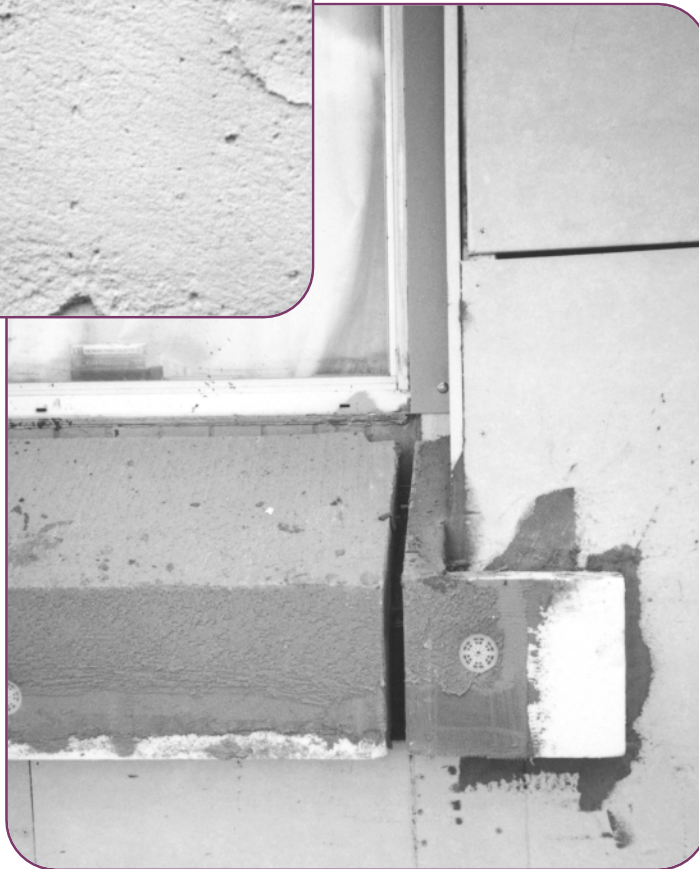
Patterned Cracking—

One of the most prevalent types of problems observed at this project related to the PM involved cracks occurring at regularly-spaced intervals throughout the wall surfaces. This patterned cracking was determined to correspond with the butt joints of adjacent insulation boards. Patterned cracking was observed at spandrel panels, shear walls, column covers, corner covers, roof eaves, notch returns, and main walls, as well as at penthouses located at the main roof levels. In addition, random cracking was observed at various locations which was attributed to diverse causes. It was noted that past remedial applications of elastomeric sealants

did not fully address this problem, and cracks extended beyond previous sealant applications in numerous areas.

Cracking within EIFS installations can occur due to a variety of causes, including defective substrates, poor workmanship, failure to comply with manufacturer's recommendations for proper installation, lamina applications that are too thick or too thin, etc. Cracking is a result of physical stresses that exceed the material's physical properties and its capacity to accommodate these stresses without detriment. Invariably, cracks have been found to contribute to water leakage within the wall system and may cause further damage due to moisture absorption, deterioration, and corrosion of materials.

Patterned cracking of the EIFS lamina was observed at regular intervals that appeared to correspond to the location of butt



joints within the insulation boards. Possible causes of this patterned cracking at insulation board joints are (a) dimensional instability of the insulation foam product, or (b) improper fastening of the insulation resulting in a "loose" substrate.

Thermal Movement—We also observed what appeared to be cracks occurring due to a lack of proper provision for accommodating expansion and contraction within the fenestration of this building. Our investigation indicated that panelization of EIFS wall cladding at this project exceeded typically recommended sizes and configurations, as well as locations where metal plastering accessories called for within the design were omitted by the installing contractor.

Deterioration of Glass Fiber Mesh—Another contributing cause for cracks occurring due to thermal stresses is a potential for EIFS membrane strength reduction due to alkali attack of the glass fiber mesh and deterioration of the fiberglass mesh associated with this physical phenomenon. The strength reduction observed within naturally-weathered, glass fiber-reinforced concrete (GFR) is well documented.³ This strength reduction is due to embrittlement of the glass fibers caused by cement hydration products that penetrate the fibers, resulting in an increased fiber-to-matrix bond strength. Although modern EIFS technology generally utilizes alkali-resistant glass fibers as well as special fiber coatings to reduce affinity of the mesh for calcium hydroxide (the primary hydration product responsible for embrittlement), strength reduction and other long-term durability problems cannot be completely eliminated. Embrittlement of the mesh was observed at this project within the remnants of EIFS materials examined during demolition of the original EIFS.

Re-entrant Corner Cracking—Cracking at re-entrant corners of various openings was also observed to be widespread and prevalent at this project. This type of crack arises due to unavoidable stress concentrations occurring at sharp angle re-entrant corners. At such locations, the stress concentrations must be either resisted or relieved. We observed cracks of this nature at the bottom corners of A/C openings and at the corners of punched windows.

Unfinished Edges—Numerous locations were observed where outside corners and terminations of EIFS panels exhibited poorly finished edges. Due to the relatively thin cross-section of EIFS, it is critical that applicators achieve full thickness throughout the panel, particularly at panel edges and corners. Failure to achieve full lamina strength at these stress points will typically result in poor performance and may cause cracking and associated water entry.

Delamination—In 1993, a relatively large section of EIFS lamina located on the East Wing, east endwall between the 13th and 14th floors fell from the building to the ground. This event caused the owner to commission an engineering investigation of the wall system, which found numerous other locations (particularly along cracks and control joints) that exhibited deficient and failing adhesion of the EIFS to associated substrates. These deficiencies prompted the engineer involved at that time to develop a program of installing supplementary fastening in the areas affected.

Upon my company's involvement, our investigation revealed that the extent of EIFS wall areas experiencing some degree of delamination went beyond those areas that had been previously addressed by supplemental fastening. In addition, the severity of

delamination varied widely from one location to another. Our observations indicated that the severity of existing delamination ranged from a narrow band occurring along cracks in the EIFS lamina to larger sections comprising several square feet in area. Our structural testing indicated that integrity of the EIFS lamina and ability to resist high wind pressures was compromised in most of these cracked areas.

Exposed Mesh—At a number of locations throughout the project, we observed areas of exposed mesh and foam. Some of these areas were attributed to poor workmanship during the original installation, while other areas were undoubtedly due to physical damage occurring during subsequent maintenance activities. Regardless of their cause, these anomalies would have required immediate repair if a decision to replace the entire EIFS cladding had not been implemented.

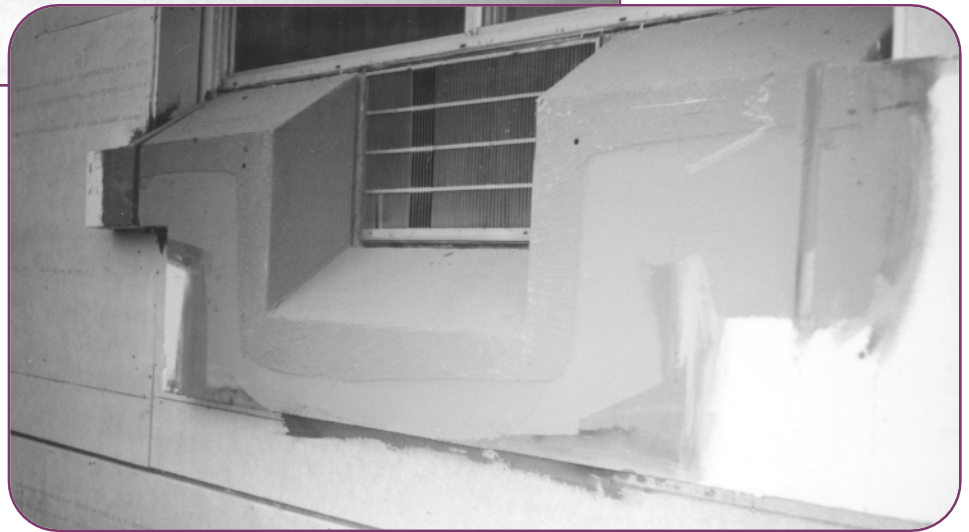
Improper Steel Framing—As previously stated, adequate slope at the window sills was effectively non-existent, because the steel framing below each opening had been fabricated perpendicular to the plane of the wall. See *Figures 1, 2, 3 and 9*. This condition could not be effectively remedied without extensive modification to the original framing. In view of the potential costs for this aspect of the renovation, this work was bid as an alternate to the base bid. Fortunately, the costs from the successful bidder were not out of line and the owner recognized the need for this modification. The alternate was incorporated into the construction contract. See *Figures 4, 5, 6, 7 and 10*. In addition, selective demolition during the renovation revealed a number of areas throughout the existing steel wall framing that were inadequately fastened to the principal structure. In addition, the wall framing consisted of excessively long metal studs that had been installed continuously across expansion joints of the building envelope.



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Left: Figure 5—Prefabricated straight sill.



Below: Figure 6—Prefabricated sill on window with A/C opening.

Use of Defective Fastener—The original PM EIFS installation was comprised of a proprietary material that utilized a galvanized fastener with a round galvanized washer that was provided with a bonded rubber washer. However, the fastener was typically installed with the rubber washer to the exterior, causing disbonding of the EIFS base coat and finish coat at a majority of the fastener locations. In addition, at a number of locations, the steel washer had cut the reinforcing mesh embedded within the base coat, causing delamination of the PM EIFS at certain areas.

Sealant Reversion—Numerous sealant problems were observed at this project related to the EIFS installation. There was widespread evidence of a particular kind of anomaly which is specific to polyurethane sealants formulated and installed between 1982 and 1989. This anomaly has been termed “reversion” and is manifested by a tackiness or uncured consistency of the sealant subsequent to installation. It is manifested by dirt retention, a lower Durometer hardness, higher modulus, and susceptibility to mud-cracking.

We observed widespread adhesive failures of the original polyurethane sealants at numerous locations, including EIFS panel-to-panel joints and EIFS-to-metal joints. Since the main cause of sealant adhesive failure is improper surface preparation, most of these failures are unquestionably due to improper workmanship during original construction.

Water Intrusion—There were numerous locations where water intrusion through the EIFS cladding was occurring in varying degrees throughout this building. This leakage resulted in water stains as well as the presence of corrosion product at certain metal components.

Water leakage into the building cladding system occurred due to a number of different sources with varying effects and degrees of severity. The most common source of water intrusion would arise from normal precipitation, including rain, snow, and ice. However, we also observed that condensate occurring dur-

ing summer months from the window air conditioning units also resulted in water entry and building component damage.

Plastering Accessories—Improper installation of plastering accessories was common and widespread throughout the EIFS applications of this project. Installation problems included variations in the field fabrication, assembly, and securement of these accessories not in accordance with recognized industry standards. Corners of the control joints were found to be improperly mitered and fitted in numerous locations, particularly around window openings but also at standard outside corners. In addition, joint accessories were terminated improperly at window recesses at all locations throughout this building. Typically, these joints did not extend into the recess, resulting in a plaster bridge subject to cracking at the end of the metal termination. See Figure 3.

The most common type of damage observed with respect to metal control joints was splitting of the metal bellows that connects the two “J”-shaped flanges and provides a certain range of joint movement. This condition represented a significant problem to be dealt with during development of any renovation plan to be implemented at this project.

Numerous cracks in the EIFS were also observed occurring at and along metal plastering accessories. These cracks occurred adjacent to control joints utilized at various locations throughout the building as well as at the perforated flanges of corner beads used at outside wall corners. Cracking of both types was wide-

spread and prevalent throughout all faces of the building cladding. Cracks were common at control joints used within the plaster membrane. Often such cracks were due to improper key-in of the EIFS materials along the bead of the joint. This condition is a result of improper application technique (i.e., lack of appropriate hand pressure) regarding the EIFS base coat, or due to dirty or oily metal accessories incorporated into the work without proper cleaning.

Pull Testing

A program of *in-situ* structural testing related to the EIFS installation at various elevations of this building was implemented. Pull tests resulted in six of the eight specimens resisting negative pressure loads that exceed the anticipated design wind pressures for this building. All but one of the samples exhibiting adequate strength had failed by the fasteners pulling through the insulation. The failure mechanism occurring in those samples not meeting the wind load consisted of the EIFS lamina disbonding and separating from the insulation. It was noted that these failed samples were located at or adjacent to EIFS surfaces that incurred horizontal patterned cracking. Based on these results, it was our opinion that cracked areas within the EIFS assemblies at this project were subject to a higher instance of delamination and posed a significant risk of additional areas failing by delamination in the future.

REPLACEMENT EIFS DESIGN CONCEPTS

Correction of Original Design and Construction Defects

The general approach utilized to design the new remedial cladding system was simply to correct (as much as possible) the detrimental conditions observed during investigation and analysis that caused or led to the previously observed problems. In addition, the firm brought to bear the cumulative experience of almost ten years of investigating EIFS projects in distress and cataloging the common and prevalent mistakes made during both design and construction. Finally, we synthesized what we considered to be the "best" procedures, details, and application methods available from the industry leaders as well as from personal knowledge of research being carried out by various parties involved in similar pursuits. All of this information was brought together to establish the basis for our design as well as to guide the design decisions made during the renovation process.

It should be noted that previous design assistance for this project by other design professionals had considered and evaluated alternative cladding system renovations including metal panels, true Portland cement plaster, and a polymer-based (PB) EIFS. Based upon preliminary pricing, and in view of the owner's limited budget, it was determined that a PB EIFS cladding would



Figure 7—Sill and A/C opening with new sheet metal flashing.

have to be the alternate ultimately pursued. Our firm was brought in to provide final evaluation of the building and to develop the renovation design ultimately used.

Provision of Enhanced Performance Capabilities for New EIFS

Based upon our experience, it was our opinion that the EIFS renovation materials for this project would have to provide performance capabilities that exceeded the previous failed PM EIFS, and hopefully avoid the mistakes and problems observed on numerous other projects. Accordingly, we endeavored to design, specify, and incorporate what we considered to be the best materials and systems into the remedial cladding. This led to specification of what would be considered as the "premium" assemblies offered at that time by a number of the leading manufacturers. A traditional PB EIFS, utilizing a barrier wall system for water management, was specified since manufacturers had not developed or marketed the "drainable" EIFS materials available today. The following paragraphs describe some of the materials and design details utilized to obtain enhanced EIFS performance at this project.

Utilization of a Premium Sheathing Substrate—Based upon the most recent industry practice, the new EIFS installation utilized a proprietary sheathing material comprised of a siliconized gypsum core with a glass fiber facer on both sides. This material reportedly has a greater resistance to water absorption and an associated decrease in sensitivity to moisture damage. Although full field testing of these claims had not been performed at the time project specifications were written, it was determined that this material would be better than standard paper-faced gypsum sheathing. In addition, an alternate substrate consisting of a proprietary, rigid, cement board was also bid; however, final budget considerations precluded its use during this renovation.



Figure 8—Elevation showing numerous windows.

reinforced mesh, avoid mesh patterning, and provide adequate cover over the mesh layer. Provisions were made at panel perimeters and the edges of wall openings to allow for the double base coat application.

Primer Application Prior to Finish Coat—Although not required or recommended by all EIFS manufacturers, a primer application on the cured base coat prior to applying the finish coat is required by a few leading manufacturers. These primers are reported to increase finish coat adhesion and enhance waterproofing performance of the overall assembly. The particular manufacturer selected for use at this project does distribute and recommend the use of a primer. The suggested application instructions

were followed as closely as possible.

Sealant Applications to Base Coat—In keeping with current industry standards as recommended by most leading EIFS manufacturers as well as the EIFS application guide, sealants occurring at opposing-side joints should be applied directly to the base coat and not to the finish coat of the joint. This type of construction requires a close coordination between the architect and the general contractor as well as proper sequencing of the sealants with other components of the building envelope.

Use of Low-Modulus Silicone Sealant—In order to avoid the stresses that could result in an EIFS cohesive failure, a low-modulus, silicone sealant having a high range of movement capability was specified and utilized consistently throughout this project. Most of these types of sealants are currently approved for use by most of the major manufacturers.

Utilization of Innovative Details

Modification of Window Sill Framing—Significant modification of the original steel framing was also specified and detailed in order to achieve proper slope of horizontal surfaces at

Two-to-One Polymer/Cement Ratio—Most traditional EIFS installations in the past typically used a one-to-one mix ratio of polymer-to-Portland cement for the base coat and adhesive components of the system. Some critics assert that this mix ratio results in a cladding assembly that is too rigid and which exhibits lowered performance capabilities. The two-to-one polymer-to-Portland cement mix ratio is believed to provide increased performance capabilities and enhance water resistance and greater flexibility. In addition, this mix ratio is reportedly more consistent with the modern EIFS applications typically utilized in Europe.

Double Base Coat—It was noted that the latest research indicates the importance of achieving a consistent base coat that is of adequate thickness as well as the critical nature of placement of the reinforcing mesh within the middle portion of the lamina. In addition, in recognition of the difficulty of workmen to achieve this “theoretical” lamina with consistent nominal thickness and the mesh placed in the middle of the coat while placing the materials in a single hand application, a second application of base coat was specified in order to fully cover the



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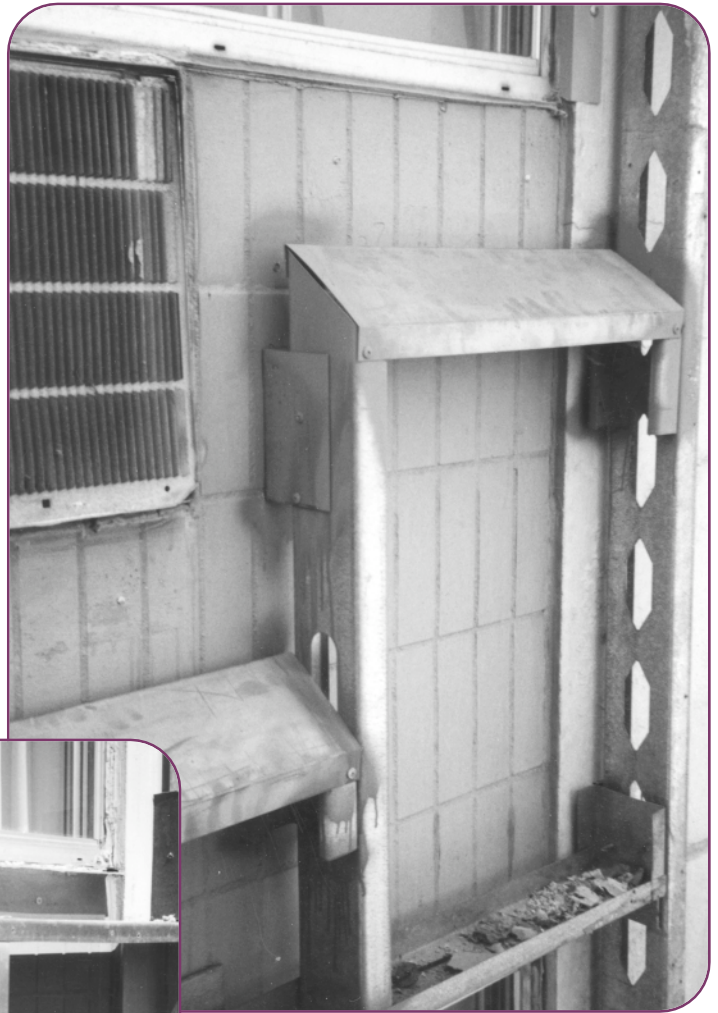
the window sills. Original sill framing had improperly created virtually flat surfaces at each window sill, resulting in inadequate drainage at these surfaces. See *Figure 9*. The renovation design was meant to correct this condition by cutting the original steel studs at a sharp angle and installing a bent plate to cap these framing members as a sloped track member. See *Figure 10*.

Prefabricated EIFS Sloped Window Sills—Due to a specific construction sequencing that we specified for the window sills and sheet metal sill flashings, the contractor developed and submitted for approval a pre-fabricated assembly comprised of foam that had been properly shaped, covered with the base coat and finish, then incorporated into the wall at the bottom of each window opening. Realizing the importance of achieving a completely base-coated foam installation (in conjunction with a sheet metal sill flashing that was to be incorporated into the wall behind the EIFS assembly at the window jambs), the contractor struck upon the idea to prefabricate the sloped portions of the sill as a method to achieve the required sequencing while allowing an acceptable production rate. See *Figures 4, 5 and 6*.

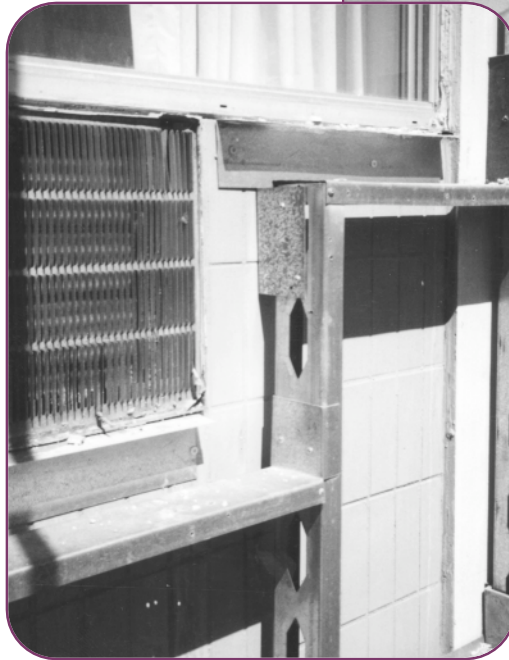
Sill Flashing Integral with EIFS at Jambs—Once the sloped sill of the window opening was fully finished, a special sheet metal sill flashing was installed in a bed of non-curing butyl sealant. Upturned end dams at each end were fastened directly to the sheathing at the recessed edges of the window opening, with the EPS foam board and finished surfaces extending down over the sheet metal at these jamb locations. The EIFS finish at the recessed jambs was incorporated into exposed front surface of the main wall systems. See *Figure 7*.

Stand-off Mounting Hardware for Appurtenances—Based upon numerous investigations of buildings having distressed EIFS applications, an attempt was made to provide specific details to support and mount various appurtenances through the EIFS assembly and onto the building structure. These appurtenances included fixed ladder brackets, sheet metal downspouts, and communication antennae. Each of these items could produce an undesirable penetration or opening through the new EIFS lamina if not detailed properly. Accordingly, special fabrications were utilized to create stand-off mounting hardware that secured the appurtenance with minimum disturbance of the EIFS lamina. See *Figures 11 and 12*.

Two-stage Sealant Joints—In addition to the use of a low modulus silicone sealant installed only at the base coat substrates, dual stage sealant applications were specified and detailed for both horizontal and vertical expansion joints within the EIFS panels created within the building fenestration. Dual stage sealant joints consist of an inner sealant bead applied against a bond breaker tape or backer rod, which is deeply recessed within the joint, as well as an exposed outer sealant bead applied against a second backer rod, creating a cavity or air



Above: *Figure 10*—Modified framing at sill.



Left: *Figure 9*—Original framing at sill.

space between the two sealant beads. The tops of panel joints are typically sealed off completely, while the air space created between sealant beads is left open at the bottom of the joint (corresponding approximately to each floor) in order to allow drainage of any water penetration as well as pressure equalization within the space.

Construction Administration, Logistics, and Progress

One of the predictable aspects of the fledgling EIFS industry is the constant change that has occurred over the last ten years, as well as that which will continue in the years to come. (Remember when it was required to apply sealants to the finish coat? When silicone sealants were not allowed?) In recognition of this and in view of the more pro-active role EIFS manufacturers began to play in the mid-1990s, we wrote our specification to include a mandatory review of the renovation construction documents by pre-qualified manufacturers. This review was intended to make sure the design concepts and details included in the renovation plan (which were based upon our experience in the

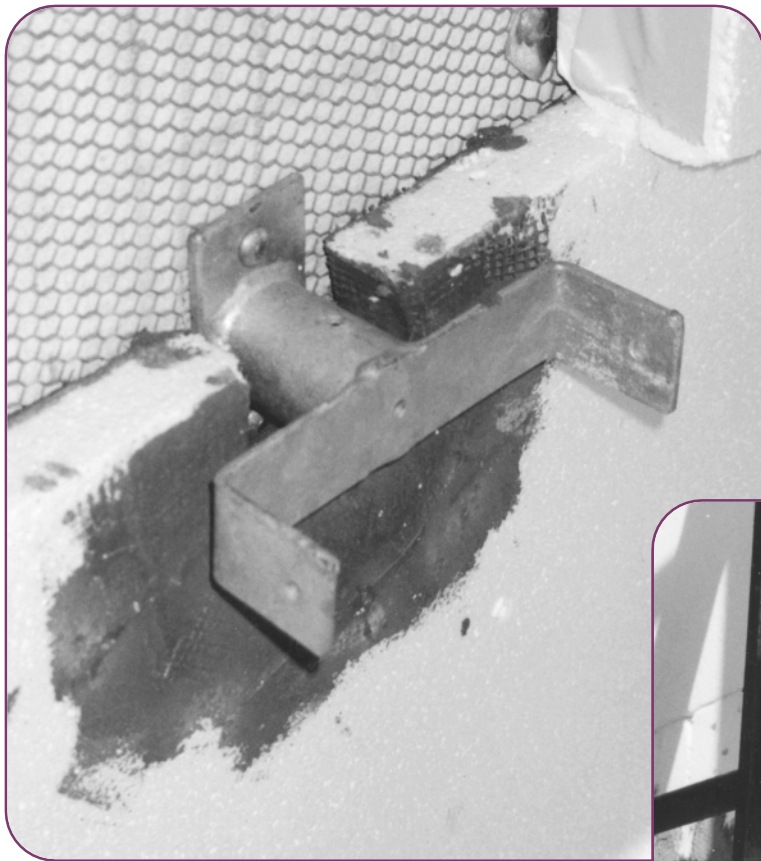


Figure 11—Stand-off downspout bracket.

industry and a synthesis of the "best" ideas from several sources), were consistent with the chosen manufacturers' latest requirements, that the project would be eligible for the long-term manufacturer warranties that had been specified, and that any conflicts, qualifications, or inconsistencies between manufacturers could be evaluated. Each of the manufacturers approached with this review burden had already implemented a mechanism to achieve the desired results and did not balk at the prospect of "approving" and providing constructive input, some of which was proprietary to their particular system. Indeed, most of the manufacturers would most likely require such a review for larger projects.

Other more common construction management procedures and methods were also utilized. These included a pre-bid conference with pre-qualified contractors, a thorough review of submittals (particularly for proposed substitutions), and mandatory attendance at a pre-construction meeting by the contractor (job-site supervisory personnel, management, and estimating), all subcontractors, the owner, the property management company, the EIFS manufacturer, the local material distributors, and representatives from HUD. The pre-construction meeting covered not only coordination efforts, logistics, and procedural matters, but it also focused on technical issues with the job-site personnel (requirements, expectations, etc.), since this was their first introduction to the project after the "hand-off" from the contractor's estimator and project manager. A job-site walk-through was also conducted to discuss various logistical matters and to point out locations where typical details would be utilized or where special procedures would have to be implemented.

Since the owners had previously been "burned" with the deficient installation of the original retrofit EIFS application, they recognized the value and benefit of implementing full-time quality assurance observations by an independent third party during progress of the work. Our firm was hired to provide these observation services in conjunction with normal construction contract administration services. The quality assurance observations were utilized to make certain that requirements of the construction documents and the EIFS material manufacturer were strictly adhered to during construction. The design firm and the design firm's on-site personnel were also utilized as a conduit for information coordination, trouble-shooting, and facilitation of the daily activities between owner, contractor, resident guests, and outside jurisdictions.



Figure 12—Stand-off ladder bracket.

In consideration of the 110,000 square feet of replacement EIFS surfaces as well as 960 window openings, the construction period was estimated to require over ten months for completion. Due to these facts, construction logistics included renovation of the building envelope over two separate construction periods during the temperate weather periods of 1995 and 1996 in order to avoid application problems associated with the harsh Minnesota winters. It was determined that the possibility of "tenting" or covering portions of the project would be prohibitive due to increased cost, lowered productivity, and remaining risks involved with freezing materials or applied components.

Due to certain unforeseen delays during the first construction period, the contractor was not allowed to start work until mid-summer 1995 and worked until early November of that year, accomplishing approximately 35% to 40% of the required work. The second construction period began in early April and continued through late October, 1996. Accordingly, the total construction period for the renovation required approximately twelve months, including weather delays, punch list development, and resolution.

One of the items perceived by the contractor to be a time and labor intensive aspect of the renovation was the specification requirement to completely finish the sloped window sills (base coat and finish) prior to installing the sheet metal sill flashing, which had to be incorporated "behind" the EIFS at adjacent window jambs. This scenario required the contractor to modify the steel framing below each window, partially apply EIFS materials at the sill, coordinate sheet metal trades to install the flashing, then resume EIFS applications at the jambs—a sequence required for all 960 window openings.

Based on our observations of past problems with other projects, we were unwilling to back off this requirement during early discussions of this issue. During the winter of 1995-1996, job site foremen struck upon the idea to prefabricate the framing modifications and sill assembly. These assemblies were then incorporated into the cladding system to facilitate construction, save time, and reduce labor conflicts.

Since access to the exterior building envelope would be required for the duration of the project, the exterior would have to be accessed using either frame scaffolding or motorized platforms. Due to the labor costs involved in erecting and dismantling frame scaffold systems, the contractor elected to use proprietary, climbing mast, motorized work platforms that were approximately eight feet deep and 60 feet wide. The weight-carrying capacity and mobility of these work platforms far exceeded those of traditional swing stages, carrying more materials and workmen as required for this project. In addition, the interval connections to the building resulted in greater stability and safety during high wind conditions. In our opinion, the contractor's use of this equipment added to the productivity and overall acceptability of the cladding renovation at this project.

OVERALL RESULTS

The overall results of the efforts expended by everyone on the renovation team, owner, designer, and contractor resulted in a cladding system that should provide acceptable performance and useful life to this property for many years to come. The new PB EIFS provides a thermally-efficient building envelope that is aesthetically pleasing and serviceable for this project. It is anticipated that the enhanced performance EIFS will perform adequately for the conditions expected, and the owner has been informed about the importance of proper and timely maintenance. Accordingly, the owner has already taken steps to implement periodic inspections of the building envelope in order to

provide an "early warning device" against problems that may be exhibited by the new building envelope. At the time of those inspections, the innovative details will be monitored in order to ascertain their effectiveness and anticipated longevity. ■

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