MUNDELEIN HIGH SCHOOL ROOFING REPLACEMENT
A case study of Superior EPDM roof system design and application.

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KEYWORDS:

EPDM, Certified Drainage, Roof System Design

When a client, especially a public entity, budgets over $2,000,000.00 (U.S) for a new roof system, there is a certain level of expectancy.

SUMMARY

This 200,000 square foot (18580 square meters) project exceeded that expectancy. A thorough predesign phase of roof system options and owner requirements were reviewed with the Owner. The design and installation challenges were many. In addition to a demanding new roof system design, masonry restoration, plumbing, carpentry, HVAC, sheet metal, asbestos removal, glazing, and drainage concerns needed to be addressed. Additionally, an adjacent new construction addition needed to be coordinated into this project. Student safety also had to be addressed. The project took 9 months to complete and is an outstanding example of how teamwork, good design, materials, and installation result in a high quality roof system. This paper will review the design approach, decision making process, Owner's expectations/concerns, along with solutions and present day thoughts.

RÉSUMÉ

Tout client avec un budget de plus de $2,000,000 (U.S.) merite un certain niveau de service.

Ce projet de plus de 200,000 square foot (environ 2200 m^2) non seulement atteint cette demande minimale mais la surpasse de loin. Avec le l'aide du client, une variete de system de couverture ont ici ete envisage mettant a jour un

grand niveau de complexite tant sur le plan conceptuel que sur le plan de l'installation. En plus de la nouvelle toiture et goutieres, un nouveau systeme de plomberie, chauffage et meme de verriere ont ete addresse. Une nouvelle structure a ete achevee en meme temp et la securite des etudiants n'a en aucun moment ete compromise. La realisation du projet pris a peu pres 9 mois et est aujourdhui un parfait exemple du travail d'equipe, d'un bon dessin,et de l'utilisation approprie de bon materiaux. Cet essaie analysera l'aspect conceptuel du projet, le processus avec lequel certaines decisions ont ete prises et la volonte exprimee voir l'attente du client en tenant compte des techniques actuelles et contemporaines.

ZUSAMMENFASSUNG

Wenn ein Auftraggeber, insbesondere eine ôffentliche Einrichtung, für eine Dachkonstruktion über 2.000.000 US$ veranschlagt, gibt es eine besondere Erwartungshaltung.

Dieses 18.580 qm große Projekt übertrifft diese Erwartungen. In Zusammenarbeit mit dem Eigentümer wurden in einer gründlichen Vorentwurfsphase verschiedene Dachkonstruktionsmöglichkeiten und die entsprechenden Anforderungen des Eigentümers erörtert. Die Gestaltungs- und Ausführungsanforderungen waren vielfältig, vor allem mussten sie in Verbindung mit den Anforderungen der neuen Dachkonstruktion, der Erneuerung des Mauerwerkes, der Rohrleitungsangelegenheiten, der Zimmermannsarbeiten, HVAC, der Metallplatten, der Beseitigung von Asbest, den Glas- und Entwässerungsanforderungen beachtet werden. Hinzu kam, dass dieses Projekt und ein benachbarter Anbau aufeinander abgestimmt werden mussten. Überlegungen zur Sicherheit der zukünftigen Studenten mussten ebenfalls mit einfließen. Das Projekt benötigte 9 Monate zur Beendigung und ist ein hervorragendes Beispiel dafür, wie Zusammenarbeit, gute Gestaltung, Materialien und Ausführung im Ergebnis eine Dachkonstruktion von hoher Qualität hervorgebracht haben. Dieser Aufsatz will einen Überblick über das Herangehen and die Gestaltung, den Entscheidungsfindungsprozess, die Erwartungen/Anforderungen des Eigentümers hin zu den Lösungen und den Überlegungen der Gegenwart geben.

RESUMEN

Quando un cliente, specialmente nel caso di Enti Pubblici, predispone una spesa di oltre 2 millioni di dollari per una nuova copertura, ha una certa aspettativa nel risultato. Questo progetto di 18.850 mq ha superato le aspettative.

Avvalendosi della collaborazione del cliente durante le fasi pre-progettuali del sistema di copertura, si sono potuti analizzare diversi sistemi costruttivi tenendo in considerazione le esigenze del cliente stesso. In aggiunta al sistema costruttivo della copertura si sono presentate diverse sfide da superare: restauro dei muri esterni, di strutture metalliche interne, modifiche al sistema idraulico-meccanico, eliminazione dei materiali isolanti ad alto rischio cancerogeno, sostituzione di vetrate e di sistemi di drenaggio. Inoltre si e' dovuto coordinare la costruzione di un nuovo edificio col restauro dell'esistente, tenendo in considerazione la sicurezza degli studenti durante le fasi di realizzazione.

Sono occorsi 9 mesi per completare questo progetto, chiaro esempio di come un buon design, il lavoro di gruppo, l'impiego di materiali di buona qualita' e una buona installazione possano concorrere nella realizzazione di un sistema di copertura di ottima qualita'. Questa relazione seguira' quelli che sono stati i punti salienti delle fasi di approccio progettuale e decisionale in seguito alle richieste espresse dal cliente, e, alcuni dei problemi che si sono presentati giorno dopo giorno nella fase costruttiva.

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Mr. Tom Hutchinson is a graduate of the University of Illinois with masters degrees in both architecture and civil engineering. Mr. Hutchinson is a licensed architect and registered roof consultant, specializing in roof design, contract document preparation, specifications, inspections and the determination of moisture penetration and failure of existing roof system. He has made numerous presentation in Europe, South America, North America and Asia. His topics have included architectural contract detailing for single-ply membrane roof systems, roofing removal and replacement, steep-slope roof systems, design, restoration and roof system maintenance. Mr. Hutchinson believes in the complete integration of all building components into a roof system design, and his work is noted for its comprehensiveness in design, detailing and specification. Mr. Hutchinson is currently a Principal and Vice President of Legat Architects, Co-Chairman CIB/RILEM International Committee on "Towards Sustainable Roofing", and is responsible for all moisture related concerns for its six studios in the Chicago land area. He is a member of ASTM Committee D-8 on Roofing, Waterproofing & Bituminous Materials, NRCA, Firestone Building Products Roof Consultant Advisory Council and is past President of the Barrington Rotary and Region Director of RCI.

INTRODUCTION

In the fall of 1995, Dr. Art Newbourgh, Superintendent of Schools, School District 120, Mundelein, Illinois, USA, a Northwest suburb of Chicago, contacted the author to begin what would be a 16 month journey towards sustaining a moisture free building. The existing 30 year plus coal tar pitch and gravel roof system reached the end of its service life years ago. Numerous cracks and splits appeared in the old roof and the base flashing had almost completely deteriorated and was in a condition that required the custodial staff to place hundreds of buckets throughout the classrooms and hallways of this 200,000 square foot facility (18,580 square meters) when rains occurred.

At the direction of the School District Board, the Superintendent and Business Manager presented to Legat Architects, their Architect for over 25 years, the challenge of designing a solution to the ponding water and leakage problems that plague the institution and overseeing the installation of a quality roof system that would service the district by passing the test of time and withstanding exposure to the rugged Chicago area climate for 30 years. The anticipated costs ($2,225,000) demanded that an extended service life be attainable.

OWNERS REQUIREMENTS/GOALS FOR SUCCESS

The project kick off meeting resulted in the establishment of the project goals. Following is a summary of those goals.

1 Improve Drainage: The existing flat roof and substantial ponding water are unacceptable and detrimental to long term roof system performance.
2 Long Term Roof System Service Life: The roof system should be designed to attain a 30 year service life. The size of the roof area and cost of replacement dictate a long service life requirement (see Figure 2). It's a sustainable issue too.
3. Plan for Future Construction: The roof design should take into account future interior renovations and the adjacent new addition simultaneously being planned, but to be built at a later date. The new interior renovations will include science room updates and a new HVAC system, requiring exhaust fan curbs and vent pipes (see Figure 5).
4. Maintenance Friendly: Where possible, maintenance free components should be used. Access to all roof areas shall be provided for maintenance of the roof and HVAC equipment. Maintenance should also begin in the design stage where it can be designed into the roof.
5. On Time Completion: The district will make early spring accommodations for the contractor, but construction should be completed by the agreed upon contracted date.
6 Costs within Budget: Fiscal responsibility on behalf of all team members is required. The budget is to be established in the predesign phase of the project.
7 Team Work: As with every major project, especially a replacement roofing project that will disrupt the entire school, a spirit of teamwork, cooperation, and enthusiasm will be required by all. Clear and continuous communication is required.
8. Maintain a Clean Project Site: While it's noted that this is a major project, it is a public project and a positive image is important to maintain.
9. Site Restoration: It is assumed that existing building and site components such as grass, concrete and interior furnishings will get damaged during the construction. Repairs and/or replacement to match the existing facility should be made at the end of the project.
10. Make Money: The Architect, Roofing Contractor, and all subcontractors should realize a fair profit on this project.
11. Safety: The roof installation process should not compromise the safety of the 1,500 students or 200 staff members.

PREDESIGN

Prior to beginning the design of the roof system, it was important to complete a number of preliminary investigative procedures that would not only effect the roof system design, but also the potential success of the project. The following tasks were performed as part of the predesign phase.

1. Field Survey:
   a) All existing building elements, as well as building components that effected or impinged upon the roof system, were located and measured for accurate placement on the roof plan: roof drains, vents, roof curbs, skylights, roof drawings, chimneys, etc. so they could be properly designed for.
   b) Masonry walls above the roof were evaluated for their ability to resist moisture intrusion.
   c) Test cuts of all roof areas to determine composition and thickness of the existing roofing were taken.
2 The existing roof system was tested for the presence of asbestos containing materials.
3. Geographical and climatic conditions were analyzed for their potential effect on the roof system performance.
4. Roof systems were reviewed for their appropriateness for this project (fully adhered EPDM and coal tar pitch were the two finalists).
5. Structural capacity of the existing roof structure was checked.
6. Code Review.
7. Defined scope of work.
8. Prepared budgetary cost estimate for the roof systems selected.
9 Reviewed potential Owner project restrictions.
10. Reviewed existing construction drawings.
11. Defined all School District restrictions.
   a) No smoking on school property.
   b) Limited area of work prior to June 1, 1996.
   c) All work to be coordinated with the Director of Facilities.

CERTIFIED DRAINAGE PROGRAM

The existing roof system ponded a substantial amount of water, which resulted in interior water damage when deficiencies in the roof surface appeared. The goal of eliminating ponding water was an important one for the Owner. Seeking to 'guarantee' the drainage, it was decided to take advantage of 'certified drainage' programs (which certify removal of water from the roof within 48 hours).

The concept of certified drainage centers around: getting the insulation manufacturer involved in the project early on; providing in field, on-site verification of the existing roof deck elevations; making field revisions when necessary; and budgeting for potential changes. Following the installation of the vapor retarder and prior to the insulation installation, the tapered insulation design team visited the project and graded out the roof utilizing a transit. Finding roof deck deflections and irregularities, the tapered insulation system could be then designed to accommodate them. The process that was followed for this project is as follows:

1. Locate the exact location of all existing roof drainage systems: gutters, scuppers and roof drains. All were located on the roof plans.
2. Design a tapered insulation system that works with the existing drainage systems while accommodating and complementing the roof system performance and ease of construction. This often involves abandoning and/or relocating the existing roof drains, installing new ones, and tying the new drain pipe into the existing. We have found that by relocating and installing new roof drains to locations that allow for geometric roof insulation layouts, that the installation of a fourway tapered roof insulation system is completed more efficiently and with greater skill than a complex layout involving switch backs.
3. Detail the roof drains appropriately.
4. Coordinate the specification requirements with those of the insulation manufacturers.

The tapered insulation Design Team returned to the project four times during the construction period to verify existing conditions. Irregularities included built up asphalt on the vapor retarder, negatively sloped roof decks and offset roof decks. Coordination allowed for corrective and appropriate action to take place prior to installation (see Figure 1).

ROOF SYSTEM DESIGN/CONTRACT DOCUMENT PREPARATION

Prior to the final design of the roof system and the preparation of the construction drawings, a final predecision meeting was held with the School Superintendent, Business Manager, School Board Members, and the project team for Legat Architects. The scope of work and budget were finalized. Two roof systems were reviewed: Coal Tar Pitch and fully adhered EPDM. The advantages and disadvantages of each were reviewed, as well as system components, current system expectations and costs. A fully adhered EPDM roof system was selected because of its excellent UV resistance, local roof crews with extensive experience in its installations, ease of installation and cost and the Architect's extensive experience in the detailing of this system and past long term successes.

The existing structure is composed of masonry bearing walls, steel beams, open web steel joists with a poured gypsum roof deck on 1" form board, with the exception of the gymnasium which is a metal deck. The components of the selected fully adhered EPDM roof system are as follows:

- Removal of the existing roof system, insulation and vapor barrier down to the existing roof deck.
- Fiberglass base sheet, mechanically fastened.
- 2 ply vapor retarder.
- Base layer of 1 1/2" inches (3.81 cm) polyisocyanurate insulation set in hot asphalt.
- 3/16 inch (.48 cm) per foot tapered polyisocyanurate insulation set in hot asphalt, 1/2" per foot (1.27cm) tapered saddles to high side of all curbs.
- 1/2" inch (1.27 cm) high density wood fiberboard set in hot asphalt.
- 60 mil EPDM set in bonding adhesive (fully adhered).
- Reinforced 60 mil EPDM set in bonding adhesive in high traffic areas.
- Laps Seams: Clean, prime, apply adhesive, seam tape after mating, roll, clean, prime apply SPM lap sealant.
- All membrane tee joints to be patched (see Figure 6A).
- All membrane vertical lap joints to be patched at angle change (see Figure 6B).

- 2'-0" x 2'-0" x 2¾" (.61 m x .61 m x 6.99 cm) rubber walkway pads.
- .063 mill finished aluminum copings, expansion joint covers, and counter flashings.

Warranty Requirements:

- 15 year Full System Roof Warranty.
- 20 year Roof Membrane Warranty.
- 20 year Sheet Metal Workmanship Warranty.
- 3 year Sheet Metal Workmanship Warranty.
- 48 hours roof drainage under Certified Drainage Program.

Auxiliary Work Items include:

- Remove existing skylights and the installation of new OSHA approved skylights and frames.
- Replace all roof drains including extension rings.
- Install new roof drains with sump pans and extension rings.
- Replace clerestory windows with new thermal windows.
- 100% tuckpointing and sealing of masonry walls above roof.
- Raise all roof curbs.
- Site restoration of damaged conditions.
  - ➢ landscaping
  - ➢ concrete and asphalt paving

As an Architect who specializes in roof system design, I believe that all building elements that impinge upon the roof system should be designed for and communicated graphically. Consequently, details are large and tell the reader what is required. We have found that work crews will utilize the drawings much more than they will a specification. The author also feels that it's a matter of duty, pride, and professionalism to have a full grasp of how the new roof system will be effected by the existing building components.

The large size of the project required some forethought prior to the commencement of drawings. The roof plan was divided into sections based on building geometry and referenced on a smaller full size roof plan. All penetrations, existing and new roof drains, skylights, tapered insulation layouts, details, and walkways were referenced on the roof plans.

In order to accommodate the new tapered insulation system to internal roof drains, the roof edge height was raised 12½ inches (31.75 cm). Various detailing scenarios were reviewed and a stepped fascia was selected to project an image of being smaller in height than it actually was (see Figure 4). Detailing was also coordinated with the new addition being designed at the same time.

Details of all the various conditions were prepared and referenced on the roof plan. The details are project specific, drawn to scale, and at a large size, (typically 3" = 1'-0")(7.62 cm = 30.48 cm). All components of the roof system are shown and fully noted to completely communicate to the contractors the design intent and required construction result. Roof system enhancements, such as tee joint patches and use of adhesive with seam tape, based on the authors extensive experience with EPDM, give assurance to a long term service life.

In addition to the removal of the existing roofing and insulation and the installation of same, the following work and trades were also required: carpentry, plumbing, HVAC, tuckpointing, sheet metal, painting, and caulking. The scope of work for all these trades was noted on the plans and detailed appropriately.

As the drawings neared completion, the technical specifications started. They were coordinated with the drawings and the requirements of the owner. As with the drawings, the specifications were project specific.

CO-ORDINATION

When the contract documents, drawings and specifications were 100% complete, they were printed and given to the author for a thorough review of each detail. After this review, the drawings were returned to the project team for final modification and revision. Coordination with the new addition and interior renovation of the existing building also took place. Roof curbs and plumbing vents for new equipment were designed into the new roof. The scope of the new construction was also included in the contract documents and bid as one so that there would be some homogeneity to the entire roof, both new and existing.

The documents were also reviewed for technical completeness, code compliance, and owner expectations.

BIDDING

A mandatory pre-bid meeting was conducted during the bidding period. During the meeting, all the project requirements were reviewed, as were the drawings, specifications and contractor qualifications. Questions were answered and meeting minutes distributed. A walk over of the roofs was conducted. Set up areas and dumpster placement were reviewed.

It was specifically mentioned that the roof contractor would hold the contracts for all subcontractors: sheet metal, carpentry, glazing, plumbing, tuckpointing, HVAC and electrical. A single point of control and coordination for all work has worked well when large responsibilities for 'keeping the building dry' exist.

On bid day, the bids were opened and were extremely competitive. The apparent low bidder was deemed non-compliant with the requirements of the request for bidders. Past experiences had also shown them to be non-responsive in emergency situations. Consequently, the apparent low bidder was not recommended for contract award. The Board of Education approved our recommendation of the lowest acceptable bid and a contract was awarded. Legat Architect's extensive history and excellent working relationship with this Company proved vital to the project's success.

CONSTRUCTION

Adding to the project challenge was a wet spring that delayed construction. Prior to the commencement of work, a pre-construction meeting was held at the school. In addition to the school and architect representatives, the contractor was required to have his on site project superintendent and foreman in attendance. We have found that as project site specific information is discussed, personnel that will be on the job should be in attendance. Additionally, representatives from all the subcontractors were required to be in attendance.

Before construction began, shop drawings, project scheduling, coordination, and logistics were submitted for review.

The Contractor proposed to have the required tuckpointing, carpentry, plumbing, existing roof tear off (including removal of asbestos containing base flashings) and vapor barrier installed prior to the installation of the new roof system, thereby reducing unnecessary foot traffic over the new roof. Roof curbs, roof edge, and expansion joint construction would also take place at this time. Since this initial phase of work took place during the school year, the district placed restrictions on the contractors as to where and when they could work. The Director of Facilities for the District and the Roof Contractor Project Superintendent worked together to coordinate a work schedule to ensure a successful roof installation without disrupting school operations or compromising safety. The Contractor altered its installation schedule to accommodate the school's requests: Plumbers worked the 3:30 – 11:00pm shift and disruptive work was choreographed across the roof to be performed at times when class was not in session. New windows, roof drain locations, and skylights were coordinated. The district permitted this work to commence during the spring semester, resulting in the completion of many of the auxiliary items prior to the onset of roofing when school was out for the summer.

Weekly meetings were held to review the project progress, review architects' and owners concerns, answer questions, and review pay requests at the end of the month.

The Contractor utilized two tear off crews and one lay-up crew. Work began in the Southwest corner and progressed Northward. The various trades were staggered to complement the project progression.

Legat Architects provided construction administration and observation services. Emphasis was placed on critical areas such as: the correct nailing of the vapor retarder bast sheet; plumbing; secure installation of the roof edge work blocking; positive insulation and membrane attachment; and clean and precise sheet metal installation.

Tuckpointing and masonry restoration work finished in May, completing a rather debris producing task. Removal of the existing coal tar pitch roof was challenging for the crew due to the nasty burns that fumes and coal tar pitch dust can produce. New roof curbs and roof drains were installed and temporarily roofed in.

After the vapor barrier was installed, members of the Tapered Insulation Design Team came on site to verify the elevations of the existing roof decks. While most of the roof areas were quite level, unknown conditions and major roof deck elevation changes and irregularities required revisions in the tapered insulation plan, roof drain location, and roof edge wood blocking.

During the weekly project meetings a permanent on site set of construction drawings was updated as part of an "AS BUILT" set.

The roof system installation was completed in early September with roof edge sheet metal following. Where new construction for the future addition was anticipated, the carpentry and roofing were installed to accommodate the new work without requiring modification.

Concerns and incorrect or unacceptable work were brought to the attention of the contractors on a weekly basis. Consequently, a final walk thru at project completion resulted in a very small 'punch list' (list of items to be corrected or completed).

While the wet spring delayed construction, innovative techniques, such as using 5 gallon (18.9 liter) adhesive buckets with holes punched in the bottom to distribute adhesive, installation skill, using 25' x 100' (7.62 m x 30.48 m) sheets, and working on weekends, resulted in the construction being completed six weeks early. Warranty inspections by the roof system manufacturer found the workmanship to be exemplary.

The new construction work and tie in went smoothly and proved that proactive coordination work can be beneficial to project costs.

POST SCRIPT/LESSONS LEARNED

School District 120, the Architect, and the Contractor deemed this project a tremendous success. Reflection on the project reveals a number of lessons that will help all to improve in the future. Following is a sample of them:

1. Communication, teamwork, and mutual respect resulted in positive impressions and relationships with project results.
2. Active Owner involvement, support, and quick decision making was critical to the project success.
3. Comprehensive construction drawings based on a thorough, well thought out scope of work told the story of what was required.
4. Quality materials, quality roof system design and installation are all required for achieving optimal service life.
5. Expeditious notification of non-compliance with the contract documents and a clean explanation of what is required and why resulted in quick rectification, and no hard feelings.
6. There are often two ways to accomplish a given task, listen, it might be a learning experience.
7. Continuous involvement of project managers with all parties was crucial as the project progressed.
8. Daily documentation of work progress, modifications, and requests for and revisions provided a historical document to review changes.
9. Photographic documentation of discovered 'unknown conditions' provided evidence for change order requests.
10 Roof expansion joints temporarily covered with a vapor barrier could not withstand the rigors of expansion and contraction. They tore open resulting in leakage. The use of EPDM as a temporary cover provided continuous protection.
11. "The roof looks terrific and is a great asset to the building and district!" says Paul Pahlman, Director of Facilities, School District 120.

A job well done and compliments leave all who participated with a sense of satisfaction.

CONCLUSION

As we move into the 21st century, the way projects are procured and completed is changing. Demand for expeditious turnarounds and lost costs often results in subpar results, which are neither desired nor environmentally responsible. The Mundelein High School District 120 project is but one example

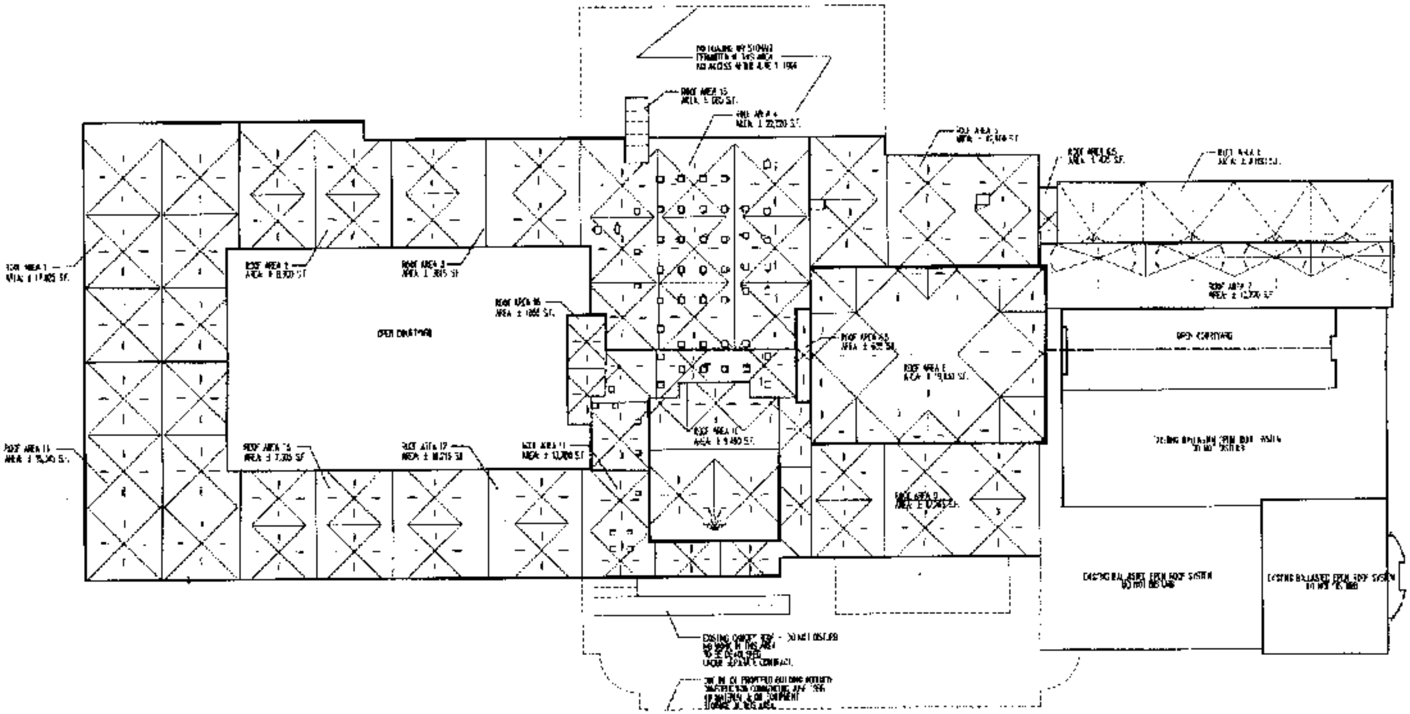

Figure 1: **Overall Roof Plan** – Fourway slope tapered insulation provides the most efficient means of achieving certified drainage. Installing additional roof drains and relocating existing drains provides for a symmetrical layout and ease of installation, which results in cost savings. Planning and designing for future additions provided continuity and homogeneity in regards to the roofing and sheet metal.

of how pride in one's work, respect for others and their needs, and a spirit of teamwork lead to the completion of a stellar roofing removal and replacement project that will achieve its optimal service life.

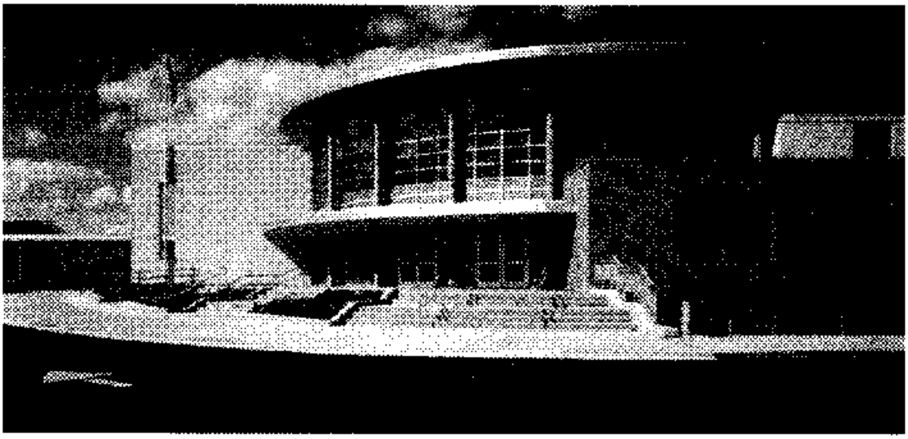

Figure 2: **Mundelein High School** - The new addition complements the existing facility. Planning for and designing for this future work at the time of the roofing removal and replacement work provided for a well coordinated aesthetic appearance.

Figure 3: **View across skylight field:** Designing and successfully installing a tapered insulation system around 36 skylights provided challenges for both designer and contractor. This heavily trafficked area received 60 mil reinforced EPDM for premium performance.

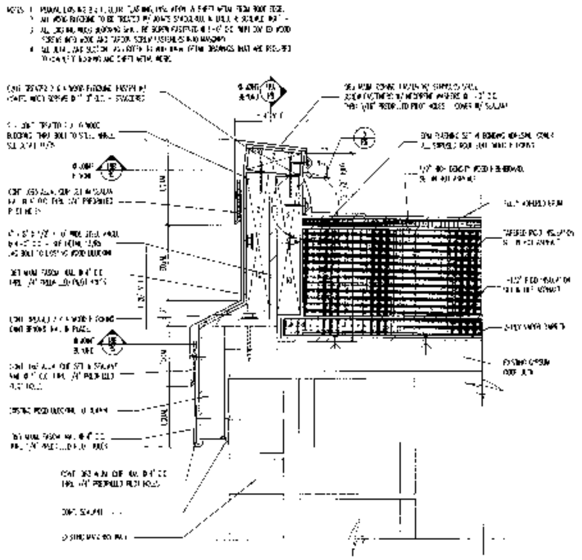

Figure 4: Primary roof edge detail showing how the roof edge was raised to accommodate the tapered insulation system. Project specific details designed and drawn for the project properly communicate to the contractor what is required.

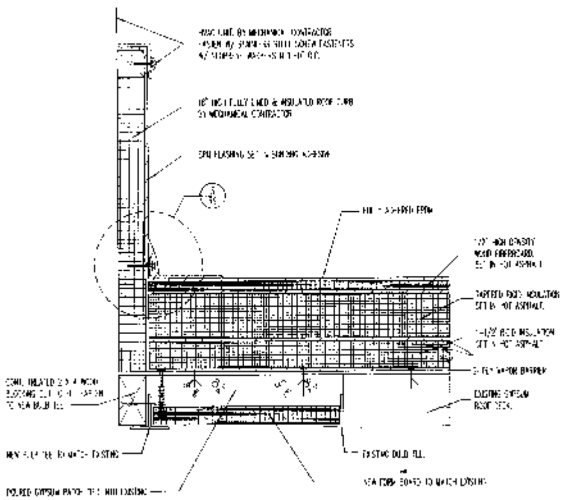

Figure 5: **New roof curb detail** - Integrating future interior renovations into the roof design prevented cutting into the new roof at later dates.

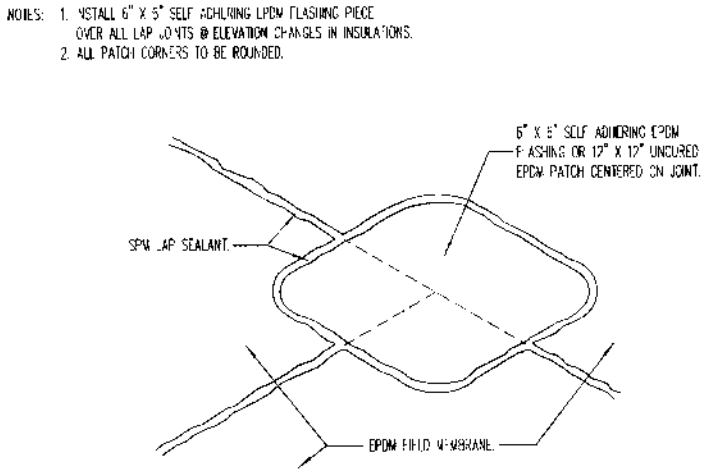

Figure 6A

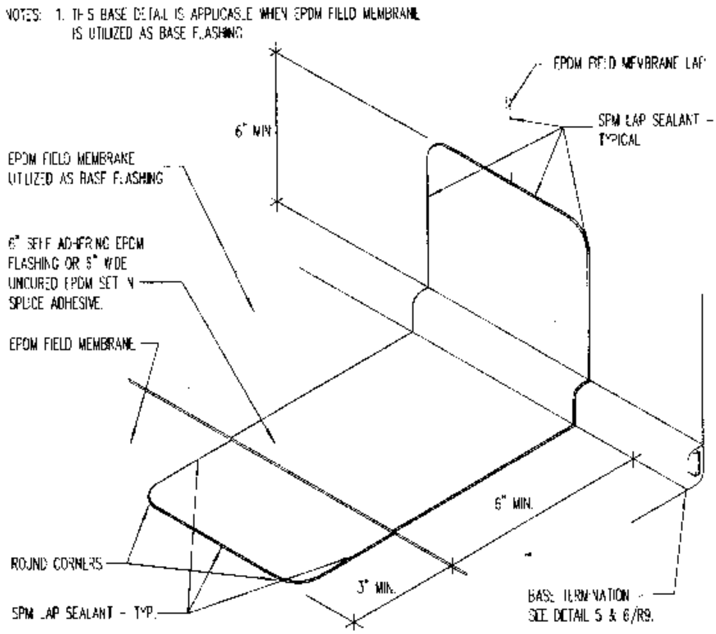

Figure 6B - Roof enhancements with detailing based on in field experience will assure long term service lives.