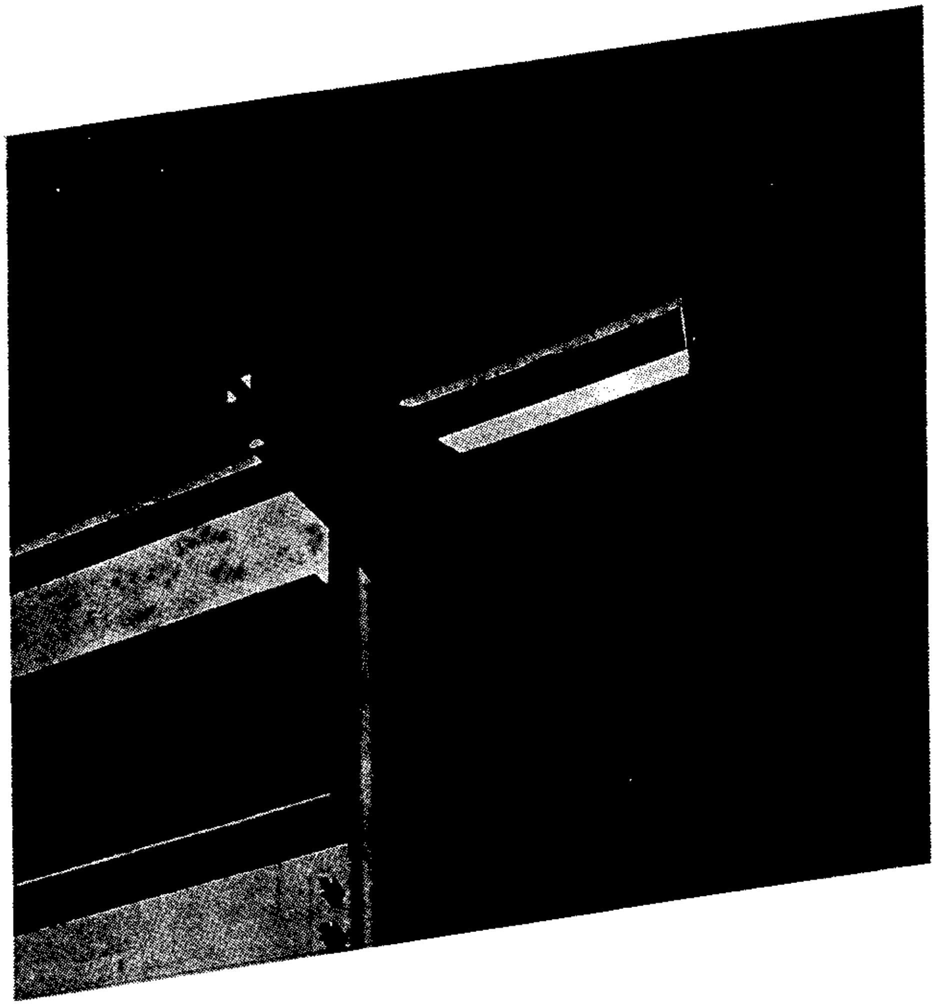
TECHNICAL PUBLICATION No. 24

Testing & Developing Durable Cost Effective Roofing Systems for Florida



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School of Building Construction
University of Florida
1983

TESTING & DEVELOPING DURABLE COST EFFECTIVE ROOFING SYSTEMS FOR FLORIDA

Sponsoring Organization: School of Building Construction

University of Florida

Cost of Research: $ 17,989.00

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University of Florida

3/31/83

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Florida Department of Education

Contract No. D.O.E. ~~083-086~~

EXECUTIVE SUMMARY

This research, an extension of the study done for research grant 081-154, was directed toward exploring the main causes of roof membrane failure. These causes are deficiencies in design, materials, installation, maintenance and inspection.

The principal investigator attended a two day seminar in Tampa on built up roof design that was coproduced by the Roofing Industry Educational Institute (RIEI)[1] and the Florida Rooofing, Sheet Metal and Air Conditioning Association (FRSA)[2]. A two day seminar in Orlando by the same group on single ply roofing was also attended to study alternate roofing systems. In addition, architects from the state of Florida General Services Administration and Department of Education were interviewed to learn their ideas on roofing design. Methods were studied that would insure good design by qualified designers for future school roofs.

The seminars mentioned above discussed material as well as design. The FRSA has started a test program on glass fiber felts for roofing, but this will not be completed until next year. A copy of a similar study[3] on glass fiber felts by the Midwest Roofing Contractors Association (MRCA) was located and is included as Appendix E. Literature on roofing material was studied extensively to develop ways of using the material most advantageously on new school roofs.

Trips were made to Tallahassee, Tampa, Orlando, Fernadino and Dunedin to interview roofers and attend meetings of the Technical Committee of FRSA. Among the roofers interviewed were: Bob Dove, President of Dove Roofing and a member of the Construction Industry Lisencing Board; Morris Swope, President of Swope & Associates and consultant to the Hillsborough County School Board; and Jim Falkner, President of Falkner Inc. and a past president of FRSA. Information was gathered and evaluated to determine the best way to install school roofs.

The principal investigator attended a two day seminar in Orlando on roofing maintenance that was coproduced by RIEI and FRSA. In Clearwater, Art Spinney, Director of Maintenance for Pinellas County Schools was interviewed. Telephone interviews with other school maintenance directors indicate that maintenance is an area that needs to be reorganized and restructered.

Inspection is the means of achieving good installation and maintenance. There is a shortage of qualified inspectors. Work was done to study a training program for inspectors while at the same time specifying ways to achieve adequate inspection until the new inspectors are trained.

At the request of the Building Construction Industry Advisory Committee this research included a study of the cost of roofing maintenance (including premature roof replacement) to the county school systems of Florida. This was done by a mail survey and follow-up interviews. The resulting answers from 52% of the counties representing 53% of the FTE students in the state are considered statistically valid. Those answers indicate that roof maintenance costs (including premature roof replacement) totaled $30,422,216 for the year 1981-82.

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FINDINGS, CONCLUSIONS & RECOMMENDATIONS

The causes for roof failure have to be caused by one or more of the following things: Design, Material, Installation, Maintenance and Inspection. By examining each of them, it is possible to list the ways each is capable of causing problems.

Design This is the process where the roof designer selects the materials he will use to roof the building. Hopefully he will choose a membrane that will work well with the deck he has designed. He also needs to be aware of the need for and the effect on the deck of insulation. He needs to be aware of the performance record of the material he has chosen in the Geographical the area in which the building is located. The designer needs to be well educated on the subject of roofing.

Very few Universities teach roofing. The situation is so critical that the National Roofing Foundation, a division of the National Roofing Contractor's Association, designed and prepared a one hour college level course on roofing.

Most architects start in practice with very little knowledge of roofing. Many take the time to learn about roofing, but unfortunately, there are some who do not. Recently, in Seminole County[4] a number of schools were designed where the roofs all failed within two years. This was determined to be a design deficiency, but unfortunately, the county was left with a substantial reroofing bill of approximately $4,000,000.

The materials for built up roofs have changed in the last 100 years, since this system has been in use. Some of the changes have been for the better, i.e. stronger felts for better membrane reinforcing. Other changes have been for the worse, such as the use of super light steel decks. One change that has not been resolved is the need to use large quantities of insulation on roofs.

When insulation first became a popular design feature in the early 1970's the National Roofing Contractor's Association sent out an "Alert Bulletin" in January 1975 warning of possible problems. C. W. Griffin, P.E. of Danville, New Jersey wrote in a 1977 paper entitled "Impact of Roof Insulation on Life Cycle Costing of Built-up Roof Systems" that:

> Thickened, more thermally resistant insulation exposes a built-up membrane to several specific life shortening effects. Roofing experts have cited the following:
>
> Accelerated chemical degradation of the bitumen
> Increased splitting hazard
> Reduced impact resistance
> Increased risk of slippage[5]

Three of the above four "life shortening effects" are related to the heat build up under the membrane caused by the presence of the insultation. There is some heat build up, but other research by Carl G. Cash and W. H. Gumperty indicated that the heat build up is in the order of 4° degrees Fahrenheit[6]. This is considerably less than the 27° difference in a white and a black roof under the same exposure conditions.[7]

In conclusion, roof designers should be educated on the subject of roofing. It is recommended that the National Roofing Foundation's course on roofing be taught at all Florida schools of architecture, and that architects and designers for school roofs be prequalified in much the same way contractors are prequalified to build schools.

<u>Material</u> Most roof designers are aware of the new glass fiber felts used in the roofing membrane. They are stronger than the older organic felts. Many designers are not aware of the changes made in the organic felts. The old

fifteen pound (15#) felt has been quietly changed to the new number fifteen (#15) felt which weighs 11 to 13 pounds per square. The new #15 felt is an organic felt rather than a 100% rag felt. The rag content of the new felt is 3 to 5% with the rest of it made up of wood fibre and recycled paper.

Organic felts and asbetos felts lose strength when they absorb moisture when stored at humidities in excess of 40%. This fact is corroborated by several researchers.[8] After being saturated in water, asphalt saturated and coated felts, both asbestos and organic, lose two-thirds or more of their strength. Storage at 90% relative humidity substantially reduces ultimate strength (by as much as one-half for saturated asbestos felts).

To store felts at relative humidity of less than to 40%, as recommended by the above research[9] would require raising storage temperature from 25 to 30 degrees F above wet-bulb temperature or dehumidifying the storage space. An alternative to this could be to have them delivered to the job in a waterproof, 6 MIL polyethelene wrapper with a dissicant inside the roll.

Glass fibre felts are usually a stronger reinforcement for the membrane than organic or asbestos felts. There are still some problems using these felts, mostly caused by wide variations in strength and weight.

The Midwest Roofing Contractors Association "Type IV Fiberglass Felt Test Results" (See Appendix E) shows the range of variations in nine brands of fiberglass felt that they tested. Each roll contained five squares of felt and the weight per roll varied from 43.78 lb to 76.90 lb. Single plies of this type of felt are requied by the appropriate ASTM specification (ASTM D 2178) to have a minimum tensile strength of 44 pounds per inch. The variation was from 23.2 pounds to 67 pounds with 6 of 9 samples testing below the minimum. When built up into 3 ply membrane the material is supposed to have a minimum tensile strength of 200 pounds per inch. The variation was from 124 pounds to 332 pounds with 6 of 9 samples again testing below the minimum. One of the rolls was not marked with the ASTM specification number. In Florida there have even been cases of manufacturers saying that if the purchaser wanted ASTM marking on the material, there would be a delay in delivery.[10]

In conclusion, it would seem that more attention should be paid to the material that goes into a built-up roof. If that built-up roof is to be made up of plies of organic felt, which is the least costly and most popular felt on the market[11], then that felt should be protected against the absorbtion of moisture. It is difficult if not impossible to store felt on a job site in Florida at a relative humidity of 40% or less, so the felt rolls should have a waterproof wrapper, such as 6 mil Polyethelene with a desicant inside.

In view of the fact that no roof can possibly be any better than the materials that go into it, those materials should be marked with the ASTM specifications to which they are manufactured, and the state should have a means of checking to see that they do meet those specifications. This is the only way that a quality control inspector on a job can be sure that the material going into the job really is the material specified.

Installation The time of installation is a time when many things can happen that will shorten the life of a roof membrane. This is true, even in cases where the best design and material are used. Poor installation proceedures can cause blistering, ridging, splitting, alligatoring and many other problems that can lead to membrane failure.

Blistering is a type of failure caused by voids in the interply moppings of a buildt-up roof. These voids can be caused by moisture in the felts, foreign matter (pebble, cigarette, pencil etc.) trapped between the plies, failure to completely mop the surface with asphalt, or falure to broom the felt into the fresh asphalt. A contributing factor is from phased construction, where part of the membrane is put down to dry in the building. Later when such a roof is finally completed there is an excellant chance that one or more of the following conditions will occur. Gravel will hae been tracked to the roof top by another trade. An exposed piece of felt will be saturated with moisture. The membrane will be puntured allowing moisture to get into the insulation.

Ridging is the formation of a ridge or hump in the roof membrane. Usually moisture is at fault, but this time the moisture usually comes from inside the building. A common cause of ridging is moisture migrating upward throughout the joints in roof insulation. This can be minimized by using 2 layers of insulation with the joints of the top layer not over the joints in the bottom layer, and by taping the insulation joints at the top surface. If there are indications that strong vapor pressure will be persent a vapor barrier should be used under both the membrane and the insulation. This is a mixed blessing in that a barrier sufficient to prevent vapor from moving up will also present water from moving down and any small leak at the surface can ruin a lot of insulation before it is discovered.

Splitting frequently is an end result of ridge movement, but not necessarily. Splitting can also be caused when inslation is free to move and puts a greater strain on the membrane than it was designed to carry. This can and should be prevented by positive anchorage of all underply insulation.

Alligatoring is caused when a thick mopping of asphalt is exposed to weathering conditions for too long. During the installation phase this can be a problem in phased construction and after the building is finished, in any unprotected areas of asphalt flood coat.

While installation is a time when a number of problems can be built into a roof, it is also the time when quality construction pays rich rewards.

In his book "Manual of Built-up Roof Systems", C.W. Griffin points out that

> "a recovered or even totally replaced roof has less chance of lasting out a 20 year service life than a new roof built with comparable care and skill".[12]

With that in mind, it is to everyone's advantage to see that a good roof is built the first time.

For the owner to be completely assured that the roof he has asked for is the roof he gets it is necessary to have an inspector on the job at all times during construction. There are two main theories of inspection. One is that the inspector should be on the job at all times and no work should be done without his presence. Some of the disadvantages of this approach are that it is very labor intensive, and in areas where good inspectors are hard to find it can delay construction. Another problem is that the inspectors very presence sometimes allows the contractor to try to shift all of his responsibility to the inspector. The other theory of inspection is that the inspector should make daily visits at random times. The theory is that the randomness of the visits will cause the contractor to do his best work all of the time. This type of inspection is not suitable for roof installation work. An inspector must be on the roof deck at all times when construction is in progress.

Maintenance After a roof has been installed it is then necessary to maintain it. This is so simple and obvious that it is difficult to understand why it is not done. The Manual of Maintenance & Operations Guidelines published by the State Department of Education in 1982 calls for annual maintenance inspections of roofs on page 31.[13]

Roof maintenance should begin even before the roof is completed, with the beginning of the historical file. A good roof historical file should include:

1. Roof plans and specifications
2. Contract documents
3. Name and address of Architect, consultant contractor, and other persons concerned with roof installation
4. All correspondence and/or notes between parties involved wilth roof installation
5. Bonds or guarantees from material manufacturers and/or roofing contractor
6. Record of all decisions and/or instructions to the roofing contractor
7. Report of each maintenance inspection with inspection with photos
8. Record of any changes made to or on roof surfaces, including mechanical or electrical installation, antennas, repair work, etc.
9. Reports of any problems and corrective actions taken.
10. Record of all maintenance work done [14]

Once the roof is completed and accepted a maintenance schedule should be set up. Normally an inspection once a year to report on and correct problems is satisfactory. Special inspections shold be made after severe storms.

Maintenance is something the owner and all of his employees should consider. At the Florida School Property Manager's Association annual meeting in 1982 mention was made of one school where the local radio club set up an "antenna farm" on the school roof and of the baseball players at another school who went up on a sprayed roof to recover foul balls while wearing their spikes.

At that same meeting, school plant managers were overheard saying that their men didn't like to go on roofs, that they didn't know what to do when they got there and besides, they didn't have a ladder that long.

One thing is certain about maintenance on roofs., If the roof membrane does not get maintained, it will fail. This is true of most parts of any building exposed to the elements, so it should be no surprise that it is true of the roof.

Flashings and counter-flashings frequently need minor patching. They are at areas likely to move, plus they are more expose to wheathering than the main body of the roof. If they are patched (maintained, if you please) the roof will continue to serve, if not, insulation will get wet leading to leakage, bubbles in the roof and big repair bills.

In conclusion, maintenance is very likely the area in which the most improvement could be made for the least investment. To achieve that will require that each built-up roof have a regular maintenance program.

<u>Inspection</u> Inspection is really two subjects in that inspection is part of getting a good installation and inspection is part of any maintenance program. Hopefully, both inspectors are knowledgeable people, but the two areas call for different kinds of knowledge.

The inspector who is watching a new roof installation has to be alert to a number of rapidly changing conditions. A roof membrane is manufactured in the field and fitted to the bvuilding at the same time. The inspector does not have the straight forward tests of say a concrete inspector who can measure the bar placement or the slump of the wet concrete etc. The roof inspector has to decide as it happens: is the fishmouth too large; is the aggregate uniformly distributed; is the interply mopping really 20 lbs of asphalt per square? The requirements of the job call for someone very familiar with the roofing process.

At the same time this inspector must if decide the membrane properly fits the deck. Are the roof drains high enough, low enough, is the flashing detail correct, did anyone track pebbles off the finished roof to a place where they can be mopped into the membrane.

While all these decisiions are being made, the inspector must be routinely checking the temperature of the asphalt as it is spread, checking the temperature of the asphalt in the kettle, checking the lap on the felts and checking the weather to be sure that work started can be finished.

Locating qualified inspectors is difficult, and convincing the owner that they are worth the money sometimes seems impossible, but the strongest defense against poor installation is quality inspection.

The inspector who makes the maintenance inspections must, like the other inspector, be a qualified person. He must know what the roof looks like when it is in good condition and he must recognize signs that say the roof is in distress. There is not the need for such fast action as there is during construction, but there is a need to initiate action very soon after faults are discovered or they can become very expensive. A maintenance inspection should follow a check list, for several reasons. First, the check list can and should become a part of the historical file of the roof. Second, there are so many things that need to be checked that it is unlikely anyone would remember then all without a check list.

The Roofing Industry Educational Institute has a very thorough check list in their literature. A good maintenance inspector can draw up his own check list. Most roofing consultants have check lists that they use.

Appendix D is a copy of a check list prepared for use in Florida.

In conclusion, roof membranes being installed must be inspected whnever work is in progress by a qualified and knowledgeable person who is either a representative of the owner or of the architect. In addition someone trained in maintenance inspection should examine every roof annually, and after storms. It can be done by the owner's representative or someone hired for the job, but it must be done by someone knowledgeable about roofs.

Annual Maintenance Costs

Since this study was sponsored by the Department of Education, an effort was made to discover the cost to the department of roof maintenance and premature replacement of roofs. A survey was conducted by mail of all county school mlaintenance directors to find the cost of roof maintenance and early roof replacement throughout the state. Not included were community colleges or universities.

Answers to the questionnaire were received from 35 of the 67 counties to which it was mailed. This represents 52% of the counties and those counties have 53% of the FTE students in attendance. This is considered a large enough sample to be very accurate. A sample of the letter is in Appendix F.

By school districts, the cost per FTE varied considerably. There seems to be no definite pattern as to whether large districts or small ones spent the most money. Some large counties had a very low FTE cost while some were high. Both the highest and the lowest cost per FTE were in rather small counties. The variation was from a low of 34¢ to a high of $269.54. The main difference between small and large counties is that large counties have roofers on the payroll in or their maintenance departments.

The total amount of money spent on roofing and early roof replacement in 1981-82 was $30.422,216.00. In the process of verifying the figures from the mail survey, calls were made to about 20% of the respondents. One question that was asked in each case was "Do you have a preventive maintenance program for your roof?" In every case except one the answer was "no". "We don't go "til there's water on the floor".

Many counties that do their maintenance only after the leak starts also pointed out that the money they spent was the money they had - not the money they needed. In one such county, when asked if they had any leaks in their 33 schools. The answer was "In every one of them". This answer indicates the need for more money or more efficient ways to use the large amount of money being spent at this time on roofs.

Implementation

The varioiuis conclusions and recommendations could, if accepted by all working in the industry, save considerable money that is spent unnecessarily on roofing. The best way for that to happen would be widespread disemination of this report.

Since this report is prepared for the Department of Education, and that is a department of the state government, it should be possible to institute or modify state laws so as to help achieve the desired ends. It may be possible to implement this report by executive action, but in any case, it seems obvious that much more money is being spent on school roofs than is desireable or necessary.

The logical implementation of this report would seem to be for the schools in the state to begin to follow the suggestions made in the various categories, i.e. design, material, application and maintenance. In order to help them, further research should be done to prepare new laws and/or modifications to existing laws that would allow:

Design - A course in roofing design shall be taught at each school of

Architecture in Florida. Also, qualifications for Architects and other roof designers shall be established in order to pre- qualify roof designers. Designers shall have their plans approved by a Certifeid Professional Roofing Contractor CPRC [15] until they meet the stat qualifications.

Material - Material for school roofs shall be marked with the ASTM specification that it meets. Asphalt and asbestos felts to be used in school roofs shall be wrapped in a water and vapor proof wrapping equal to 6 mil polyethelene and shall have a dessicant inside the package. Every effort will be made to use Florida manufactured material in Florida schools.

Installation - All roofing installations shall be done by a contractor who has passed the state roofing contractor's examination. All roofs shall be inspected as they are installed on a daily basis by a qualified inspector, until qualfications can be established, a CPRC shall be retained to do this inspection.

Maintenance - Each school roof <u>must</u> be inspected at 12 month intervals and an inspection form (similar to Appendix E) will be completed. Pictures will be made to accompany the forms and copies of each will be sent to the department of Education. Action shall be taken within one month of the inspection to correct any problems. If action is not initiated at the local level, it shall be at the state level.

Inspection - Standards must be established for construction inspectors and for maintenance inspectors. The use of qualified inspectors at the time of installation and during maintenance checks should be required. Qualification for these spectors must be established and until such time as there are sufficient qualified inspectors, the inspections shall be made by a CPRC.

DISCUSSION

During the year that this study was being conducted the Principal Inspectigator attended seminars on roof maintenance, single, ply roofing and roof design. These seminars were sponsored by the Roofing Industry Educational Institute (RIEI) and the Florida Roofing,, Sheetmetal and Air Conditioning Association (FRSA). This was the first time any of these seminars have been presented in Florida.

The Principal Investigator also attended 3 meetings of the FRSA Technical Committee. This group has been most helpful with the research and have been generous with theier time and knowledge.

One day was spent in Tallahassee with Mr. Rene Vallaradez, an architect with the Florida General Services Administration. He is with the group that does most of the state's work relative to roofs except school roofs. Ond day was spent with the Office of Educational Facilities Construction and the people who approve school roofs.

A paper on School Roof Maintenance was presented by the author on built-up roofs at the annual meeting presented the opportunity to interview a number of the people attending and were very useful.

At other times a number of roofers, roofing consultants ans school plant managers were interviewed. (see Appendix B). In addition, roofs were inspected at various stages of constructino and a great deal of reading and studying was done.

Analysis of Annual Maintenance Costs

DISTRICT	FTE	ROOF MAINTENANCE	COST PER FTE
Alachua	23,145	$1,036,744.75	$ 44.79
Baker			
Bay	21,768	47,563.69	2.18
Bradford	4,474	185,000.00	41.35
Brevard			
Broward	144,640	400,000.00	2.77
Calhoun			
Charlotte	8,454	10,800.00	1.28
Citrus			
Clay	17,906	21,081.54	1.18
Collier	15,948	22,650.00	1.42
Columbia	7,321	74,500.00	10.18
Dade			
DeSoto	4,157	200,000.00	48.11
Dixie			
Duval	105,410	3,408,656.00	32.34
Escambia			
Flagler			
Franklin	1,893	125,000.00	66.03
Gadsden			
Gilchrist			
Glades	1,009	271,965.00	269.54
Gulf			
Hamilton	2,586	62,640.00	24.22
Hardee			
Hendry			
Hernando	8,182	100,000.00	12.22
Highlands	8,069	59,840.39	7.42
Hillsborough	118,214	3,000,000.00	25.37
Holmes	3,584	240,000.00	66.96
Indian River	10,057	32,837.48	3.27
Jackson	8,153	41,651.34	5.11
Jefferson	2,258	1,000.00	0.44
Lafayette			
Lake	18,762	50.000.00	2.66
Lee			
Leon			
Levy			
Liberty			
Madison	3,406	1,175.00	0.34
Manatee	23,252	84,570.00	3.64
Marion			
Martin			
Monroe	8,274	68,469.45	8.22
Nassau			
Okaloosa			
Okeechobee	5,064	140,112.00	31.85
Orange	89,632	129,044.56	1.44

DISTRICT	FTE	ROOF MAINTENANCE	COST PER FTE
Osceola	10,372	$ 150,000.00	$14.46
Palm Beach			
Pasco			
Pinellas	98,944	2,125,000.00	21.45
Polk			
Putnam	10,978	7,040.80	0.64
St. Johns			
St. Lucie	15,290	50,000.00	3.27
Santa Rosa			
Sarasota	26,530	32,711.00	1.23
Seminole	39,221	4,000,000.00	101.99
Sumter	4,792	25,000.00	5.22
Suwannee			
Taylor			
Union			
Volusia			
Wakulla	2,637	32,030.96	12.15
Walton			
Washington	4,031	2,500.00	0.62
TOTALS	878,417	$16,260,376.00	
STATE TOTAL	1,643,467[16]	$30,422,216.00	18.51

FOOTNOTES

1. Roofing Industry Educational Institute (RIEI) of Englewood, Co is a non-profit organization sponsored by members of the Roofing Industry.
2. Florida Roofing, Sheetmetal and Air Conditioning Association (FRSA) of Orlando FL is an association of members of the Roofing Industry in Florida.
3. Midwest Roofing Contractor's Association Inc. (MRCA) of Kansas City Mo is an association of members of the Roofing Industry in the Mid-western part of the United States.
4. Interview with Hugh Carlton, Director of Auxillary Services, Seminole County, FL, May 17, 1982.
5. C.W. Grifin, P.E., "Impact of Roof Insulation on Life Cycle Costing of Built-up Roof Systems" Proceedings of The Symposium on Roofing Technology London, England 1981 P 370.
6. W.J. Rossiter & R.G. Mattingly, "Effects of Insulation on The Temperature of Roof Membranes". National Bureau of Standards Proceedings 66-987 of February 1976 P-11.
7. Carl G. Cash & W.H. Gumpertz, "Economic and Performance Aspects of Increasing Insulation on the Temperature of Built-up Roofig Membranes" Journal of Testing and Evaluation, (ASTM), VI, 5, No 2, March, 1977, P 124.

8. C.W. Griffin, P.E., Manual of Built-up Roof Systems 2nd edition (New York: McGraw Hill, 1982) P-318.

9. Op. Cit.

10. Interview with Bob Dove, President, Dove Roofing Company, Tallahassee, Florida, October 11, 1982.

11. Girffin, Manual of Built-up Roof Systems P- 140.

12. BID., P-337

13. Florida Department of Education, Office of Educational Facilities, Manual of Maintenance & Operations Guidelines, April 1982, Section 3.05 P-31.

14. Robert E. Crosland "Roof Maintenance Manual" 1983 P-1

15. Certified Professional Roofing Contractor, (CPRC) is a Professional Roofer who, in addition to the State Roofing Examination, has passed an advanced examination given by the FRSA.

16. Interview with Chris McConnell, Maintenance Supervisor, Office of Education, State of Florida, Tallahassee, FL, March 21, 1983.

APPENDIX A

Scope of this Research

As stated in the proposal for this research: "It is the purpose of this new investigation to persue those leads (uncovered by the previous investigation.......081-154), thereby continuing the ongoing effort to expand a data base of roofing information at this University that can be used by the entire construction industry".

In addition this research included a study of the cost of roof maintenance and early roof replacement to the county school systems of Florida.

APPENDIX B

Persons Contacted

Paul Tente, Roofing Consultant; Denver, Co

Jerry Dykenhuisen, General Manager FRSA; Orlando, FL

Terry Tougaw, Architect for Alachua County School Board, Gainesville, FL

Rene Vallaradez, Architect with GSA, Tallahassee, FL

Gordonn Dirkes, Architect & Consultant; Winter Haven, FL

R. L. Fricklas, Director RIEI; Denver, Co.

Gorham Rutter, Dept. of School Planning & Construction; Orange County, FL

Sanford Roth, Pres. Roth Bros of Fla-Roofer; Tampa, FL

Hugh Calden, Director of Auxillary Services, Seminole County Schools; FL

Edward W. Barnard Jr., Consultant; Jacksonville, FL

Ronna J. Werner, Chief Estimator, Roth Bros Roofing; Tampa, FL

Bob Dove, President, Dove Roofing; Tallahassee, FL

John Carlson, Facilities Planning, Univ. of Fla; Gainesville, FL

Harold Blaylock, Chief Maint & Const. Univ. of Fla; Gainesville, FL

Morris Swope, Pres. Swope & Assoc.; Roofer; Tampa, FL

Art Spinney, Director of Maintenance; Pinellas Co, FL

Myer Rosenburg, Roofing Specialist, CERL; Champaign, IL

Don Brotherson, Roofing Researcher, Univ. of Ill; Champaign, IL

Jim Falkner, Pres. Falker Inc., Roofer; Orlando, FL

Chris McConnell, Chief of Maintenance, D.O.E.; Tallahassee, FL

Paul Krone, Dir. O.E.F.C. D.O.E. Tallahassee, FL

Ed F. Krone, Dir. O.E.F.C. D.O.E., Tallahassee, FL

Robert P. Light, PE Building Official & Enforcement Officer Sarasota, FL

Kurt F. Eisman, Chief Bulding Inspector, Palm Beach county, FL

APPENDIX C

Summary of Costs

Salaries		$ 11,589.00
Secretary		1,200.00
Expenses		5,200.00
	Total	$ 17,989.00

From: Roof Maintenance Manual

Prepared by:

Robt. E. Crosand
Architect

APPENDIX D

ROOF INSPECTION REPORT FORM

Building No. ______________ Date of Inspection: ________________
Inspected by: ____

ROOF MEMBRANE

1. General Appearance:
   Good _________ Fair _________ Poor _________

2. Watertightness:
   No leaks reported ____________
   Leak reported at (give location)
   ____

3. Reported leak occurs:
   Every rain ___________________
   Only with long continued rain ___________
   Only with high winds ______ Direction of wind? ________
   Only when ponding occurs ______________

4. Condition of Aggregate:
   Uniformly distributed ________________
   Bare areas _________________
   Inadequate amount of aggregate _______________
   Excess amount of aggregate _______________

5. Condition of Membrane:
   Uniform coverage of bitumen __________________
   Exposed edges of felt ______________________
   Edges of felt curled _____________________
   Blisters in felt ______________________
   Fishmouths in felt _______________________
   Tears, splits, cracks in felt ________________
   Felt dried out _______________________
   Buckling or sagging of felt ________________
   Alligatoring of bitumen __________________

6. Recommended Treatment of Membrane:
   ____
   ____

APPENDIX D

FLASHINGS

1. Base Flashings:
   - Good Condition ____________
   - Deteriorated surface ____________
   - Vertical joints open ____________
   - Base of flashing loose ____________
   - Sagged or separated from parapet wall ____________
   - Tears, splits or cracks in base felt ____________

2. Counterflashing:
   - Well-anchored in masonry ____________
   - Condition of caulking at masonry ____________
   - Bonds, buckles or damage to metal ____________
   - Lap joints sealed ____________

3. Coping:
   - Good condition ____________
   - Lap joints sealed ____________
   - Bends, buckles or damage to metal ____________
   - Loose fasteners ____________

4. Vent flashing (lead boots):
   - Good condition ____________
   - Base flange loose ____________
   - Boots turned down into vent pipes ____________
   - Holes or damage to lead boots ____________

5. Chimney vents:
   - Good condition ____________
   - Base Flange loose ____________
   - Collars sealed ____________
   - Rain caps secure ____________
   - Galvanized metal painted ____________

6. Pitch Pans:
   - Good condition ____________
   - Base flange loose ____________
   - Filled with bitumen ____________
   - Galvanized metal painted ____________

7. Gravel Stops:
   - Good condition ____________
   - Lap joints sealed ____________
   - Bent, buckled or damaged metal ____________

APPENDIX D

8. Dissimilar Metals:
No dissimilar metals in contact ______
Dissimilar metals are insulated or isolated ______
What metals are involved: ______
______

9. Recommended Treatment for Flashings:
______
______

DRAINAGE SYSTEM

1. Scuppers:
Open and in good condition ______
Sealed to flashing ______
Base flange sealed ______

2. Roof Drains:
Open and in good condition ______
Sealed to membrane ______
Deterioration of metal ______
Condition of strainer ______

3. Gutters
Open and in good condition ______
Securely fastened ______
Lap joints sealed ______
Bent or damaged metal ______

4. Downspouts:
Open and in good condition ______
Securely fastened ______
Bent or damaged metal ______
Splash blocks in place ______

5. Recommended Treatment for Drainage System:
______
______

GENERAL HOUSEKEEPING

1. Cleanness:
Roof is clean and free of trash and debris ______
Found liter. Type ______
Found loose objects. Type ______

2. Painting & Caulking:
   All ferrous metals well protected ____________
   All masonry/concrete surfaces sealed ____________
   What areas need caulking? ____________
   What areas need painting? ____________

3. Dissimilar Metals:
   No dissimilar metals in contact ____________
   Found dissimilar metals in contact;
   type ____________

4. Repair Work Recommended:
   ____
   ____

TYPE IV FIBERGLASS FELT TEST RESULTS

Midwest Roofing Contractors Association, Inc.
1000 Power & Light Building
Kansas City, Missouri 64105

November, 1981

APPENDIX E

Midwest Roofing Contractors Association, Inc., the members of its Technical and Research Committee and its technical advisors shall not be deemed by anything herein to have recommended the use or non-use of any particular glass felt and they do hereby disclaim responsibility for any consequences which may result from reliance upon any of the contents hereof or the use of a particular glass felt for a particular application.

APPENDIX E

At our request, Structural Research, Inc., Madison, Wisconsin, undertook a fiberglass testing program. The purpose of the program was to determine how the various ASTM D2178 Type IV fiberglass roofing felts marketed in the Midwest performed when measured against the following two standards:

1. ASTM D2178 which requires that Type IV fiberglass felt have a minimum tensile strength of 44 lb/in.

2. NBS Building Science Series 55, Preliminary Performance Criteria for Bituminous Membrane Roofing, Section 6.1 which recommends roof membranes have a tensile strength of not less than 200 lb/in in the weakest direction when tested at 0°F. ASTM D2523 is the recommended test procedure.

ASTM felt tensile strength tests were run on both dry felts and on felts which had been subjected to a 48 hour (70°F) water soak and a 24 hour (140°F) water soak. ASTM D2523 test procedures were run on three-ply membranes constructed from dry felts and on three-ply membranes constructed with felts which had been subjected to the 48 hour (70°F) water soak.

SAMPLING PROCEDURES

One roll of ASTM D2178 (Type IV) fiberglass roofing felt from each of nine different manufacturers was procured from various points within the Midwest. The sample rolls were selected at random from warehouse inventories and forwarded to the testing laboratory in Madison, Wisconsin. Instructions were given for packaging and shipping. All rolls were cartoned and protected to prevent handling and shipping damage.

Upon receipt, all roll wrappers were checked for a statement of conformance to ASTM D2178 (Type IV) standards. The Certainteed Certaglass roll wrapper was the only wrapper which did not indicate any conformance to or identification as an ASTM D2178 (Type IV) glass roofing felt. The rolls were checked for damage, weighed in and tagged for identification. The roll weights are listed in Table 1.

TESTING PROCEDURES

Individual fiberglass felt samples were taken from both the longitudinal and transverse directions of the rolls as described in ASTM Method D146, Section 12.1. Samples were placed in a water bath for a 24 hour and 48 hour period respectively. The 48 hour water bath temperature was maintained at 70°F ± 5°F for the duration. The 24 hour water bath was maintained at 140°F ± 5°F for the duration. The water soak samples were removed from the water bath and had the excess water blotted off; they were then allowed to air dry for a minimum of 48 hours. These samples were then tested for tensile strength according to ASTM D146, Section 13.1 and ASTM D828.

Three-ply built-up roof membrane samples were constructed out of fiberglass felt samples taken directly from the roll as well as samples which had been subject to a 48 hour (70°F) water bath. The three-ply samples were constructed under laboratory conditions, by means of a press which closely controlled both application temperature and interply mopping weight. The same batch of asphalt was used for all 3-ply samples.

TEST RESULTS

Glass Felts

A wide variation between fiberglass felt strengths was found to exist in the transverse felt direction (27.8 lb/in to 64.9 lb/in) for the test lot, with the average being 48.8 lb/in. After a 48 hour (70°F) water soak, the test lot yielded a transverse felt strength range of 26.7 lb/in to 66.5 lb/in, with an average of 46.4 lb/in. The felt samples which were subjected to a 24 hour (140°F) hot water soak yielded a transverse felt strength range from 23.4 lb/in to 52.0 lb/in, with an average of 39.4 lb/in overall for the test lot; the results are shown in Table 2.

On the average, the test lot of nine different fiberglass felts retained 95.1% of their strength when subjected to the 48 hour room temperature (70°F) water soak. The test lot subjected to a 24 hour warm water (140°F) soak retained 80.7% of its strength on the average.

Three-Ply Membranes

The test lot materials which were laid up in three-ply membranes (with a top coat) were tested at 0°F; transverse strengths ranged from 151 lb/in to 332 lb/in, with an average for the test lot of 208.6 lb/in. Three-ply membranes which were assembled with glass felts subjected to a 48 hour (70°F) water soak (and then air dried) exhibited a loss of strength; transverse strengths ranged from 124 lb/in to 280 lb/in, with a test lot average of 193.2 lb/in when tested at 0°F. This represented an average retained strength of 92.7%; by comparison the glass felt strips had retained 95.1% when tested as a mat alone. The results are shown in Table 3.

COMMENTS

Only one roll of each manufacturer's glass felt was tested. The rolls tested represent only a small sample of the inventory of glass felt roofing rolls which existed in August and September of this year when the test rolls were obtained. Therefore, while the test results are accurate as to the individual rolls tested, the test results should not be viewed in any manner as being conclusive as to all rolls of glass felt but rather, only indicative of tensile strength differences which may exist among the various glass felts currently marketed in the Midwest. Also, since a wide variation was found to exist among the nine glass felts, it may be that tensile strength variation will exist among the rolls of glass felt manufactured by any one manufacturer or among the plants of any glass felt manufacturer with more than one manufacturing plant.

The test results also indicate that water soaking can be detrimental to the tensile strength of glass felts. A closer look should be taken at the strength loss glass membranes may experience over wet fill decks and other high moisture substrates.

TABLE 1

ROLL WEIGHTS - AS RECEIVED

ROLL IDENTIFICATION	ROLL WEIGHT (LBS)
TAMKO TAM-GLASS	64.69
GAF GAFGLAS PLY 4	57.04
CONGLAS CONPLY A IV	62.63
OWENS-CORNING PERMA PLY NO. 11/IV	76.90
OWENS-CORNING PERMA PLY-R	43.78
EVANS PERMAGLAS TYPE IV ULTRAPLY	53.85
CERTAINTEED CERTAGLASS	60.80
JOHNS-MANVILLE GLASPLY	58.20
CELOTEX CELO-GLASS IV	54.88

NOTE: ALL ROLLS ARE 5 SQUARE

TABLE 2

STRENGTH OF FIBERGLASS FELTS (LB/IN)*

SAMPLE	LONGITUDINAL			TRANSVERSE		
	TAKEN DIRECTLY FROM ROLLS	48 HOUR (70°F) WATER SOAK	24 HOUR (140°F) WATER SOAK	TAKEN DIRECTLY FROM ROLLS	48 HOUR (70°F) WATER SOAK	24 HOUR (140°F) WATER SOAK
1. TAMKO TAM-GLASS	58.2	58.6	50.9	57.4	51.6	48.5
2. GAF GAFGLAS PLY 4	61.9	64.4	62.4	55.7	58.1	49.1
3. CONGLAS CONPLY A IV	60.4	58.5	53.7	53.2	42.3	42.0
4. OWENS-CORNING PERMA PLY NO. 11/IV	66.6	61.7	53.1	44.3	38.0	33.0
5. OWENS-CORNING PERMA PLY-R	67.0	58.5	57.3	64.9	66.5	52.0
6. EVANS PERMAGLAS TYPE IV ULTRAPLY	34.5	34.6	23.2	27.8	26.7	23.4
7. CERTAINTEED CERTAGLASS	51.1	51.2	39.3	50.5	49.5	38.9
8. JOHNS-MANVILLE GLASPLY	49.4	46.7	35.9	41.2	40.3	29.8
9. CELOTEX CELO-GLASS IV	48.2	50.3	40.5	44.1	44.9	37.7

* SINGLE PLY OF FELT; ASTM D 2176 MINIMUM TENSILE STRENGTH OF 44 LB/IN; TESTED AT ROOM TEMPERATURE AT 2 IN/MIN ACCORDING TO ASTM D 2178

TABLE 3

STRENGTH OF BUR MEMBRANES (LB/IN)*

SAMPLE	LONGITUDINAL		TRANSVERSE	
	TAKEN DIRECTLY FROM ROLLS	48 HOUR WATER SOAK	TAKEN DIRECTLY FROM ROLLS	48 HOUR WATER SOAK
1 TAMKO TAM-GLASS	243.5	264.7	222.7	234.2
2. GAF GAFGLAS PLY 4	243.3	253.0	224.7	192.3
3. CONGLAS CONPLY A IV	250.8	215.5	172.0	182.8
4. OWENS-CORNING PERMA PLY NO. 11/IV	254.2	248.8	162.3	171.0
5. OWENS-CORNING PERMA PLY-R	318.7	255.3	332.0	280.0
6. EVANS PERMAGLAS TYPE IV ULTRAPLY	158.8	152.7	151.0	124.0
7. CERTAINTEED CERTAGLASS	151.6	190.0	202.3	171.5
8. JOHNS-MANVILLE GLASPLY	216.3	213.2	189.7	167.4
9. CELOTEX CELO-GLASS IV	231.0	237.3	221.3	216.3

3 PLY MEMBRANES; NBS BUILDING SCIENCE SERIES 55 RECOMMENDED MINIMUM TENSILE STRENGTH OF 200 LB/IN IN THE WEAKEST DIRECTION; TESTED AT 0°F AND 0.08 IN/MIN

UNIVERSITY OF FLORIDA • GAINESVILLE 32611 • SCHOOL OF BUILDING CONSTRUCTION

Dear

Presently I am at work on a research project for the Department of Education. This project concerns roof problems. I am trying to determine the cost of such problems to each county.

You will be of tremendous help in this research if you fill in the blank below and return this letter to me in the enclosed stamped envelope.

Thanking you in advance, I am

Yours very truly,

Prof. Luther J. Strange, Jr. P.E.
School of Building Construction
University of Florida

Last year our county spent approximately ____________ on roof maintenance. List any qualifications.