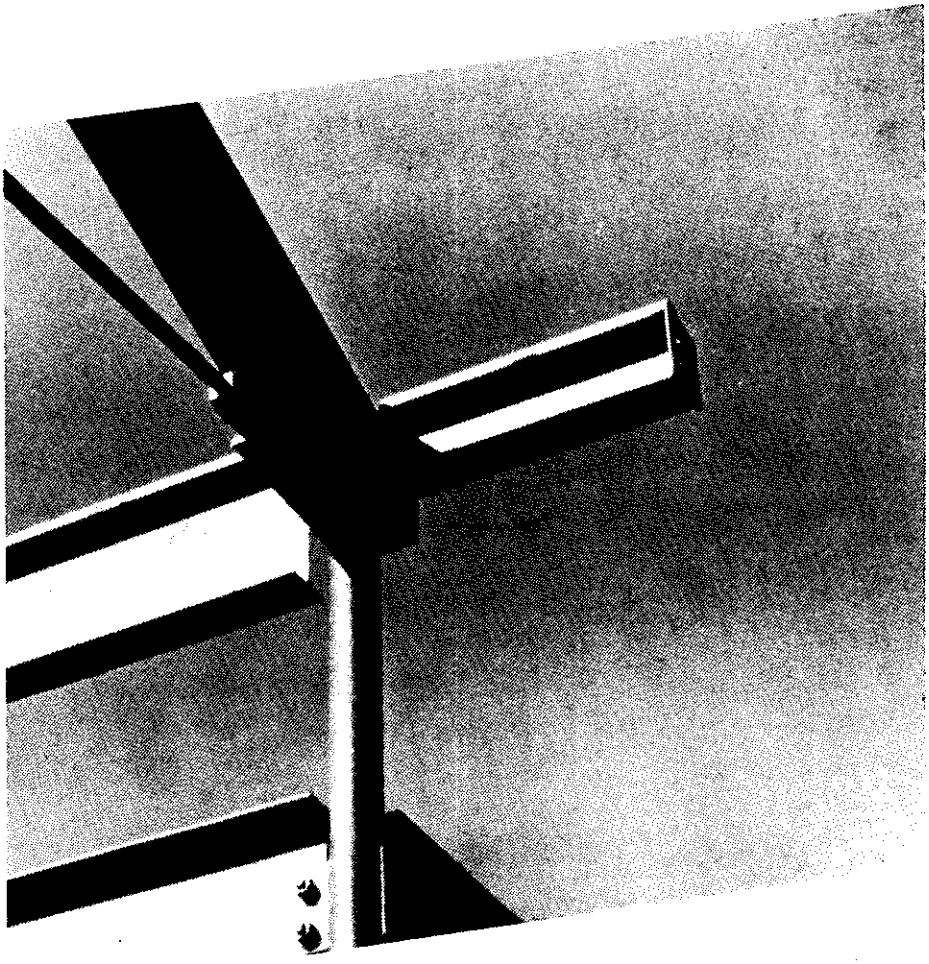
TECHNICAL PUBLICATION NO. 36

Research and Development of Guidelines for the Reduction of Life-Cycle Costs of Roofing in Florida



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1984

RESEARCH AND DEVELOPMENT OF GUIDELINES

FOR THE REDUCTION OF LIFE-CYCLE COST OF ROOFING IN FLORIDA

A report of the Construction Research Project
by Associate Professor Luther J. Strange Jr. and
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School of Building Construction, University fo Florida
Gainesville, Florida
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EXECUTIVE SUMMARY

The continuing problem of school roofs that fail was addressed in this report. Researchers traveled around the state and determined that some areas were experiencing a much lower rate of failure than other areas. The report explores what kinds of roofing practices lead to long lasting roofs. A questionnaire was sent to maintenance people in every county asking for their roofing procedures. Through this survey, researchers discovered that the most common public school roof -- flat built-up -- is also the design with the greatest number of failures in recent years.

As a result of observation and the questionnaires, it became obvious that good maintenance was the key to longer lasting roofs, and a roofing maintenance manual was appended to the the report. Research indicated that school officials knew what maintenance needed to be done, but that regularly scheduled maintenance simply was not carried out. Good inspections also lead to good roofing, researchers found, and inspection is necessary both when new roofs are being installed and as part of a maintenance program later. A manual to guide the training for inspectors and to serve as a check list is included in the report.

The quality of roofing can also be improved by requiring roofing contractors to meet certain requirements. The researchers recommend that contractors prequalify to bid on school work, and listed specific prequalifications that should be met.

Even if a roof has been installed correctly according to National Roofing Contractors Association recommendations, roofs sometimes fail due to ponding. This is caused by deflection from rapid rainwater buildup due to a shallow slope or to too few and small drains. The researchers recommend modifying the building code requirement for flat roof slope. Further steps should be taken to require adequate drain spacing and sizing.

Two safeguards to Florida's school roofs would be 1) independent testing of products that go into the roofs, and 2) labeling of all roofing materials to show exactly what specifications the materials meet. Another specific suggestion is to eliminate roofs that fail because of "phased construction", which happens when the roofing contractor is prodded by the general contractor to "dry-in" part of the building or to finish the roof during adverse weather. Phased construction often leads to moisture in the membrane, a very common cause of roof failure. Further, the researchers recommend that a glaze coating of asphalt or pitch be applied to all exposed felts at the end of each working day.

One of the reasons little maintenance is done on school roofs is a flaw in the way the state has paid for roofing. If a county maintains its roofs, the money comes from the county school budget's limited maintenance funds. However, if the roof is neglected until it is unrepairable, the county is eligible for state funds to install a new roof. A bill to change this situation has been presented to the state legislature. The bill took the researchers' suggestion that districts that do not execute a regular maintenance program must bear the entire cost of roof replacement.

The failure of school roofs is a continuing problem for the state of Florida, and this research report is an effort to modify that situation. In the course of this study, both investigators have traveled around the state looking for solutions. In the course of those travels,it became evident that some areas have less trouble than others. It also became evident that those areas with the least number of problems were those areas that have done the best job of following what is considered to be good roofing practice.

With this in mind, a questionnaire was prepared (Appendix I) and mailed to the maintenance people in each county. The results of this questionnaire were disappointing (only 15% returned them) and frightening (80% of the respondents admit they have no regularly scheduled maintenance program).

Other things about the questionnaire were disturbing also, in that some of the numbers simply did not add up. One county answered question #6 which asks, "What types of alternative have you tried on your flat roofs?", with this statement: "All re-roofing of the flat roofs in our district are processed in accordance with state requirements and we employ some type of taper system." This same district said that they replaced 1500 squares. That would indicate a roof life of 8 months. Another district reported 60,000 squares of flat roofs - none built- up and no alternatives have been tried.

All in all the results of the surveys were somewhat useful in that they showed that there are still a high percentage of flat roofs -- most of them built-up now on schools. The size of the sample is a limiting factor, but it would appear that the most flat roofs are found

near the large cities, while smaller school districts seem to have a smaller number of flat roofs.

The survey also indicated that most of the flat roofs are built-up roofs. Built-up roofs are the type that have been giving the most trouble in recent years. This problem, which has been very expensive for the state of Florida, has begun to concern the roofers who build roofs in Florida.

In the spring of 1984 the Florida Roofing, Sheetmetal, and Air Conditioning Contractors Association, Inc. (FRSA) set up a "D.O.E. Specifications Task Group." The purpose of this group is to prepare a thorough guide to the basic process of educational facility construction as it applies to roofing and re-roofing. This FRSA Task Group invited University of Florida researchers to their meetings and they have prepared a very comprehensive guide to present to the D.O.E. architect and his staff. (A copy of the guide is enclosed as Appendix II.)

Nothing discovered in this study would indicate that there are any factors other than design, material, installation and maintenance that have a serious effect on roof life. Of course it is fairly obvious that in order to get proper material, installation and maintenance there must be good inspection, so perhaps that should be added as a fifth factor.

Travels undertaken in pursuit of this report, included the National Roofing Contractors Association (NRCA) meeting in Atlanta Georgia, work with FRSA committees in Tallahassee and Orlando as well as visits to building and school administrators in Yulee, Tampa, Clearwater, Tallahassee, Orlando, Jacksonville and Titusville.

At each stop it became more and more apparant that the fastest way to improve roof performance will be to improve maintenance. Poorly maintained roofs lose their ability to serve the purpose for which they were designed at a rapid rate. A well designed roof that is poorly maintained has less of a chance to last than a poorly designed roof that is well maintained. With this in mind, this study includes a roofing maintenance manual (Appendix V).

The problem with maintenance for school roofs is not in the maintenance manual, it is in getting the maintenance done. The Maintenance and Operations Guidelines of the state D.O.E.[1] calls for regular maintenance of school roofs, but it is simply not done.

Perhaps one of the reasons maintenance is not performed is the fact that the way the state pays for school roofs is an actual dis-incentive for the counties to maintain their roofs. At this time, if a county maintains its school roofs, that money comes out of limited funds available to do all maintenance on schools. If, on the other hand, the county chooses to ignore school roofs until they can get an architect or engineer to certify them as unrepairable, then that county is eligible for state funds to install a new roof.

It would seem only fair to the taxpayers of the state to institute a funding formula whereby school districts failing to comply with the roof maintenance program must bear the entire cost of replacement. (Note: this is one of several recommendations for school roofing which are gathered in Appendix III).

In order to maintain any sort of maintenance program, and for that matter to oversee proper installation of roofs, good inspections are

required. At this time, such inspections as those that new roofs get is provided on a random basis. Some architects provide some inspection. Some school districts have some inspections. As a general rule, it cannot be said that roofs are inspected as they are installed. Nor can it be said that there is adequate inspection done as part of the maintenance program either. With this in mind, certain standards must be set to require the certification of roofing inspectors.

Inspection should also be required on all school roof installation. Recently, some twenty-year old roofing was removed from Clearwater Senior High School and the "three ply" roof was observed by an investigator to have only one ply. With the service life of current roofs, this simply cannot be allowed to happen again.

As part of this investigation, a manual has been prepared to guide in the training of and serve as a check list for inspectors. (See Appendix IV).

Some school districts require that contractors who bid on their work meet certain requirements before they are allowed to bid. In effect, they prequalify the contractors who can bid on their work. In so far as prequalification can improve the quality of work done on school roofs, and it can, it only makes sense that the state of Florida have a minimum prequalification for all school roofing work. These prequalifications should include at least three parts:

1. Any bidding contractor or subcontractor shall have an established record of successful installation and performance of roofing systems on commercial, industrial, or academic buildings within the State of Florida, for which

documentation relating to management personnel shall be required.

2. Bidding contractor shall, prior to bidding, be approved or certified by the manufacturer for the application of the system which is bid.
3. Bidding contractors shall, prior to bidding, have an office in the county in question or in any contiguous county.

The state of Florida specifications for roof slope of "flat" roofs calls for 1/4" per foot slope on new roofs and 1/8" per foot and/or use of adequate drains on re-roof jobs. This is a standard set of numbers, coming from the National Roofing Contractors Association recommendations. The problem with the numbers is deflection; deflection caused by rapid rainwater buildup, too few or too small drains or by deflection itself.

According to C.W. Griffin in his book Manual of Built-up Roof Systems[2],

> "Ponding caused by faulty design can be explained as follows: The deflection curve produced by an accumulating weight of rainwater may form a shallow basin in a roof. If the outflow does not prevent the capacity of the basin from increasing faster than the influx of rainwater, the roof is unstable, and a long continued rainfall is structurally hazardous."

One obvious way to avoid the conditions outlined above is to include deflection in all calculations. Perhaps a better way to state this would be to modify building code requirements for flat roof slope not less than ¼" per foot after deflection is calculated. This is one of the recommendatons for school roofs coming from this research.

Another method of preventing the situations outlined by Mr. Griffin from happening is to increase the amount of drainage on a roof. Many texts on the subject of roof drainage urge that the drainage be through interior drains.[3] The reason given is that inside drains are less likely to be damaged by outside sources - parking cars, etc. He does suggest that in milder climates exterior drains are acceptable. This investigation does not verify that.

Mr. Griffin has some very pertinent ideas on the subject of number of drains and how to locate them. His book shows a table, compiled from data supplied by the Josam Manufacturing Company that lists maximum anticipated rainfall per hour for various locations. The same book also lists flow capacity for various pipes relative to the slope of the roof. That chart is reproduced herein. (Figure 1)[4]

Pipe Sizing Data

Pipe diameter, in.	*Flow Capacity for storm drainage systems, gpm*			
	Roof drain and vertical leaders	*Horiz. storm drainage piping*		
		Slope, in./ft		
		⅛	¼	½
2	30			
2½	54			
3	92	34	48	69
4	192	78	110	157
5	360	139	197	278
6	563	223	315	446
8	1208	479	679	958
10		863	1217	1725
12		1388	1958	2775
15		2479	3500	4958

The rain chart shows a high rainfall in Florida of 4.6 inches per hour. This works out to require a 4" drain for each 4,000 square feet of roof area. Inches per hour can be converted to gallons per minute with the following information:

1 cubic foot of water = 7.5 gallons

1 cubic foot = 1728 cubic inches

1 gallon = $\frac{1728}{7.5}$ = 230.4 cubic inches

Therefore 1 inch/h/sq.ft. = $\frac{(144)}{230.4}$ - 60 = 0.0104 gpm/sq.ft.

With 4.6 inches per hour a possibility, in Florida we get :

4.6 X 0.0104 = 0.0478 gpm/sq.ft.

According to Figure 1 (above), a 4" drain pipe has a maximum capacity of 192 gpm. Therefore, with a capacity of 192 gpm, 4000 sq. ft. is all a 4" round drain pipe can safely drain. This calls for a drain spacing of no more than 63 feet in any direction. The use of a 3" drain cuts the distance to 45 feet and the use of a 2" drain calls for a drain every 25 feet in any direction.

In order to make certain that there is sufficient drainage on school roofs to avoid an unstable situation, steps should be taken to specify suitable spacing and sizing of roof drains. This is one of the recommendations made in Appendix III.

As long ago as 1975[5] there was a call for independent testing of products that go into school roofs. This was also recommended in the first research report prepared by the University of Florida.[6] This is even more important today than when the need was first stated. More and more new roofing materials are appearing on the market, and many of them are untested,[7] especially in the unique environment of Florida. This was confirmed by Hal Davies of Trumbull Asphalt Company, Atlanta.[8]

Mr. Davies pointed out that due to the shortage of good labs in Florida, there is a very good chance that uncertified, non-specification asphalt may be finding its way into school roofs. Mr. Davies was in favor of the idea, set forth in the first research report mentioned above, of the University setting up a laboratory to test materials going into state work. Mr. Davies was kind enough to say that if the decision were made to set up such a lab, he would be willing to help us get started.

Another item relative to the above has to do with the marketing of roofing materials relative to the specifications that they meet. Some roofing material manufactureres do not put the ASTM specification that their material is supposed to meet on the package. Others say that to mark each roll of felt will call for an extra charge.

It is felt that this investigation shows there is a need for independent testing of new roofing systems and materials as well as a need to label all roofing materials that will be used in school roofs to show just what specifications they do meet. This is included in the Recommendations for School Roofing that is Appendix III of this report.

Many of the practices in roofing that lead to failure are listed and explained by Mr. John A. Walson in his book Roofing Systems: Materials and Application:[9]

1. Dead level roofs that pond with water.
2. Moisture-sensitive and absorptive organic roofing felt and insulation materials where repelling water is the primary objective.
3. Low-density plastic foam and glass-fiber insulation.
4. All forms of thermal insulation sandwiched between a vapor barrier and a built-up vapor-impervious roof covering.

5. Insufficient number of piles of roofing felt and bitumen to resist thermal shrinkage.
6. Roof decks containing excessive moisture, causing blisters.
7. Roof decks that allow excessive movement between pre-formed units.
8. Roof decks that allow excessive temporary or permanent deflection under load.
9. Unpredictable shear strength at the roofing-substrate interface.
10. Any form of fixed immovable mechanical fastening of soft compressible insulation to roof decks, or nailing roofing components through the insulation.
11. Use of mineral-surfaced cap sheet roofing over mopped felts, especially when nailed on low slopes.
12. Improperly designed flashings.
13. Roof drains of insufficient size, number, style, and placement to drain a roof quickly.
14. Lack of regular maintenance by owner.
15. Mixing coal tar and asphalt products in the same roof.
16. Mixing asphalt saturants, filled coatings, and unfilled hot moppings that are not compatible with each other.
17. Use of roofing gravel that is not opaque to ultraviolet light.
18. Application of membrane roofing on roof inclines that are too steep or that have variable inclines.
19. Roof specification not suitable for the interior or exterior environment and roofing in wet weather.

20. Use of black smooth surfaced asphalt roofs over insulation and without a heat reflecting surfact coating.
21. Installation of electric conduit on top of the roof deck and within the thermal insulation layer.
22. Lack of control over construction-phase moisture within the building.
23. An important aspect of roofing performance is application procedure and workmanship, and also materials handling and storage.

Nearly half of these refer to moisture within the roof membrane itself. One of the primary ways that moisture gets into the membrane is by what is called "phased construction". This is what happens when the general contractor prods the roofing subcontractor into putting on part of the roof to "dry in" the building, so that other trades can work inside. The second part of this "double whammy" comes when the general contractor is ready to complete the building and encourages the roofing subcontractor to finish the job right away. This frequently means during periods of less than ideal weather and the chance of trapping moisture in the membrane are excellent.

The solution to the above happening is to prohibit "phased construction" on school roofs. If the general contractor thinks he might need to work ahead of the roofing contractor, then let him include in his bid the price of a temporary roof; this roof to be used during construction and then removed before the start of the finished roof. There is a school of thought that says the temporary roof can be prepared and then used as a vapor barrier under the permanent roof. This seems to defeat the entire purpose of the temporary roof. It is felt that the temporary roof should be removed.

The investigators on this project recently had an opportunity to see this entire scenario acted out on an addition to the building in which they teach. First the insulation and two plies of roofing were put over the addition. They were not glazed. Two months later, after an all night rain, the roofer appeared, swept some of the water off the roof, set some pitch pockets, mopped down an additional ply of felt and finished the roof. The roof was finished with a flood coat of asphalt and a coat of gravel. Three months later the roof began to leak.

It has been recommended in Appendix III that the Department of Education prohibit phased construction of base and ply sheets and require GLAZE coating of asphalt (or pitch) on all exposed felts at the end of each working day. It should be noted that asphalt and pitch are incompatible materials and the proper one should be used for this glaze coat.

Footnotes

1. Office of Education Facilities, Manual of Maintenance and Operations Guidelines, (Tallahassee, FL, Florida Department of Education, April, 1982) p. 31.

2. C.W. Griffin, Manual of Built-up Roof Systems, 2nd ed. (New York, NY, McGraw-Hill Book Company, 1982) p. 40.

3. Griffin, ppg. 27-35

4. Griffin, Ibid.

5. "Roofing Seminar, Sept. 26, 1975" being the report of a two day seminar held in Jacksonville, FL Sept. 25 & 26, 1975.

6. Luther J. Strange, Jr., An Investigation of Premature Roof Failures in Florida. (Gainesville, FL, School of Building Construction, University of Florida December, 1981).

7. Interview with Bob Dove of Dove Roofing Company, Tallahassee, FL, 10/17/83.

8. Phone interview with Hal Davies, Laboratory Director, Trumbull Asphalt Company, 1/13/84.

9. John A. Watson, Roofing Systems: materials and applications. (Reston, VA, Reston Publishing Co., Inc. 1979). p. 263.

APPENDIX I

April 3, 1984

We hope that our research into roofing problems in Florida public schools can be of real help to you, either now or in the near future. Our studies involve the design, materials, installation and maintenance of roofing systems for improved life-cycle costs. We offer our technical assistance in any roof problems you may face, and will soon provide seminars and short courses to help up-date your personnel in roof inspection and maintenance procedures.

But right now we need your help! Yes, we need information from EVERY COUNTY in the state in order to provide the over-all data base necessary to accomplish our goal. Our goal is, of course, to save tax dollars--millions of them -- through cost-effective roofing.

So PLEASE take the time to complete the enclosed questionnaire, and return it promptly in the self-addressed, postage free envelope. In helping us, you will be helping yourself and other school administrators throughout the State.

Thank you for your cooperation, and please feel free to call on us if we can be of assistance.

Sincerely,

Robert E. Crosland

Sincerely,

Luther J. Strange Jr.

Luther J. Strange, Jr.

NAME_____

Adress _____

QUESTIONNAIRE

Note: If you would like a summary of this information when it is assembled, please check here _____

1. Does your county have a regular roof maintenance program?

   Yes _____ No _____

2. If the answer to #1 is yes, how often are roofs inspected?

   Annually _____ Semi-Annually _____ Other _____

3. Approximately how many squares of roofing are in your area? _____

4. Of the above, approximately how many squares are "flat" roofs? _____

5. Of the "flat" roofs, approximately what percentage are built-up roofing? _____

6. What types of alternative have you tried on your "flat" roofs?

   _____

   _____

   _____

7. Were you satisfied with the alternative roofing?

   _____

   _____

8. Approximately how many squares of flat roofing do you replace each year? _____

9. Does your county retain the services of a computerized maintenance program? _____

   If yes, what firm? _____

   _____

   _____

APPENDIX II

FLORIDA ROOFING SHEET METAL & AIR CONDITIONING CONTRACTORS ASSOCIATION, INC.

FRSA CREDIT UNION
FLORIDA FORUM MAGAZINE
FRSA SERVICES CORP.

P.O. DRAWER 4850 • WINTER PARK, FLORIDA 32793
305/671-3772

SELF INSURERS FUND • P.O. Box 4907 • Winter Park, Florida 32793

TO: DOE SPECIFICATIONS TASK GROUP (LES KNOPF, DEAN ROLLINS, MORRIS SWOPE, CPRC, DEBBIE LIFTIG, TOM BALDAUFF, CPRC, LUTHER STRANGE)

FROM: JERRY DYKHUISEN, GENERAL MANAGER

DATE: AUGUST 9, 1984

RE: FINAL DRAFT

Attached is the (hopefully) final draft of our recommendations to DOE. Read them over and let me know of any changes that need to be made.

If no changes are suggested, our next meeting will probably be in Tallahassee with the DOE representatives.

/sar

Enclosures

BASIC PROCESS - EDUCATIONAL FACILITY CONSTRUCTION

I. LOCALLY RESPONSIBLE ENTITY DETERMINES NEED AND PETITIONS DEPARTMENT OF EDUCATION FOR FUNDING.

II. DEPARTMENT OF EDUCATION APPROVES PROJECT.

III. BIDDING PROCESS BY ARCHITECTS, ENGINEERS, AND/OR CONSULTANTS (DESIGN ENTITY).

A. Prequalification

1. Any bidding entity shall have an established record of successful commercial, industrial, or academic building performance within the State of Florida, for which documentation relating to management personnel shall be required.

2. Any bidding entity shall have the ability and means to provide qualified, daily on-site supervision.

B. When the above qualifications are satisfied, the bidding process may proceed according to statute.

IV. PLANS ARE DEVELOPED THROUGH WORKING DRAWINGS AND SPECIFICATIONS.

A. Working documents shall include:

1. New construction.
   a. Complete dimensional architectural roof plan with details including equipment locations, roof penetrations, roof slopes, drains, and scuppers.
   b. Specifications shall be complete and current.

2. Reroof/retrofit
   a. Complete dimensional architectural roof plan with details including equipment locations, roof penetrations, roof slopes, drains, and scuppers.
   b. Specifications shall be complete and current.
   c. Detailed description of the existing roof system and a history of repairs drawn from on-site inspection and verification.
   d. Certification by a structural engineer to accept additonal and ancillary loads.

B. In an conflict between sound roof design and asthetics, sound roof design shall prevail.

C. Proprietary specifications are prohibited.

V. DEPARTMENT OF EDUCATION CHECKS BID DOCUMENTS FOR CONFORMITY WITH GUIDELINES.

A. It shall be the responsibility of the design entity to insure compliance will all manufacturer's recommendations as well as those of the Department.

B. It shall be the responsibility of the design entity to insure that all specifications meet the requirements of the Standard Building Code as a minimum. Nothing in these rules shall prevent specifications which are more stringent in their requirements than those found in the Standard Building Code.

VI. BIDDING TAKES PLACE.

A. Prequalification of contractors and subcontractors.
1. Any bidding contractor or subcontractor shall have an establishd record of successful installation and performance of roofing systems on commercial, industrial, or academic buildings within the State of Florida, for which documentation relating to management personnel shall be required.

2. Bidding contractor shall, prior to bidding, be approved or certified by the manufacturer for the application of the system which is bid.

3. Bidding contractors shall, prior to bidding, have an office in the county in question or in any contiguous county.

B. Prebid conference for roofing shall be held on all projects with bidder's attendance mandatory.

C. Once the above qualifications are met, bidding process may proceed acording to statute.

D. Bid is awarded, contract discrepancies resolved, and contracts are signed.

E. Required performance and payment bonds and product submittals are provided.

VII. WORK COMMENCES WITH CHECKS BY DESIGN ENTITY AND DEPARTMENT FOR CONTRACTOR COMPLIANCE.

A. Prework conference held to determine each party's position and responsibility.

1. Walk through of construction site shall be included.

2. Letter from design entity should be provided which certifies roofing substrate for compliance with contract documents. The roofing contractor shall only be responsible for accpetance of the completed substrate surface and detail items.

3. Any special conditions are noted with methods for resolution being specified.,

4. Job site inspector's duties and responsibilities are agreed upon.

B. Job site inspector notified of official starting date. Daly inspection to be provided.

VIII. WORK IS COMPLETED AND FINAL INSPECTION MADE. CERTIFICATES ISSUED. WARRATIES AND MAINTENANCE SCHEDULE RELEASED TO DEPARTMENT.

A. A certificate of substantial completion shall be issued by the design entity within 15 working days of a contractor's written request for inspection.

1. At the time of this inspection the contractor shall be given a detailed list of items to be completed and/or corrected, including a reasonable time frame for their completion.

2. Roofing contractor shall be provided with a release of responsibility for subsequent changes or damage by other trades.

B. The contractor, upon completion of required work, shall make written request for final inspection. Within 30 calendar days of such request, design entity and Department representatives shall perform such inspection and, if appropriate, certify completion. Warranty period shall begin at that certification.

C. If a manufacturer's warranty is to be provided, it shall be the contractor's responsibility to arrange for the mechanics of the manufacturer's inspection and certification.

D. In the absence of a manufacturer's warranty, the attached standard warranty shall be used. (Copy attached)

E. Whatever the warranty, the design entity shall warranty the suitability of the roofing system specified.

F. Copy of "Roof Maintenance" by the Roofing Industry Educational Institute to be provided by DOE to local school board.

IX. PERIODIC INSPECTIONS AND MAINTENANCE TAKE PLACE.

A. Historical file established and maintained by local school board.

B. A minimum of semi-annual inspections will be made on each roof, noting any changes in the roof plan on file. Quarterly inspections are recommended.

C. Maintenance and emergency repairs are handled in accordance with "Roof Maintenance" from RIEI.

D. During every inspection, debris will be removed from the roof and all roof drains cleared.

APPENDIX III

OUTLINE OF RECOMMENDATIONS FOR SCHOOL ROOFING

Research and Development of Guidelines for the Reduction of Life-Cycle Costs of Roofing in Florida. DOE 084-015

REQUIREMENTS FOR LOCAL SCHOOL BOARDS

1. Require organized roof maintenance program for ALL school roofs, including semi-annual inspections and reports of inspections.

2. Pre-qualify roofing contractors for ALL school roofing work, with the following minimum qualifications.

   a. Roofing contractor shall have established record of five years successful installation and performance of roofing systems on commercial, industrial or institutional buildings within the State of Florida, for which documentation relating to management personnel shall be required.

   b. Roofing contractor shall be approved or certified by the manufacturer for the application of the system or product which is bid.

   c. Roofing contractor shall be bondable for performance and payment bond.

3. Require full-time inspection during application of roofing, by qualified roofing inspector.

REQUIREMENTS FOR STATE DEPARTMENT OF EDUCATION

1. Institute funding formula wherby school districts failing to comply with roof maintenance program must bear the entire cost of replacement.

2. Provide certification of roofing inspectors by:
   a. Seminars/short courses throughout State.
   b. Examination or proven experience in roofing.
   c. Correspondence course and examination.

3. Modify building code requirement for flat roof slope not less than ¼" per foot after deflection is calculated.

4. Limit maximum distance of water travel from any point on roof to the point of drainage. Such limitation to consider slope, surface type, and material.

5. Require independent testing of NEW roofing systems, and require all roofing to be labeled to show which standards they meet (i.e. A.S.T.M.).

6. Prohibit phased-construction or base and ply sheets, and require glaze coating of asphalt (or pitch) on all exposed felts at the end of each working day.

APPENDIX IV

ROOF INSPECTION MANUAL

FOR BUILT-UP ROOF SYSTEMS

SCHOOL OF BUILDING CONSTRUCTION
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

ROBERT E. CROSLAND

LUTHER J. STRANGE, JR.

CONTENTS

ROOF INSPECTION MANUAL

INTRODUCTION

Inspections by competent personnel should be used to accomplish two important functions:

1. For quality control during the application of new roofing, re-roofing, or any major roof repair.
2. As a key element in an effective roof maintenance program.

Quality control inspection should be full-time throughout the application, re-roofing or repair process to verify compliance with the contract documents, and insure good workmanship. Competent and timely inspections are the best "guarantee" of roofing quality. Such inspections provide checks on materials, methods and workmanship. In addition, knowledgeable inspectors may detect errors in design so that they can be corrected without costly delays or call-backs. Inspection is particularly important when contracts are awarded on the basis of low bids.

All roofing requires proper maintenance to achieve it's intended life-expectancy, and competent periodic inspections are vital to any roof maintenance program. Good maintenance can add years of useful life to a roof, and provides the most cost-effective means of insuring trouble-free service. Maintenance inspections should be made at least twice each year, preferably each Spring and Fall. In addition, special inspections should be made after any severe storm, or other event in which roof damage might have occurred.

RECORD KEEPING

A historical record should be set up and maintained for each roof from the time the roofing is installed. Roof plans and all related

contract data should be included in this file. All inspections should be recorded on report forms (see appendix), and follow-ups made to insure that any recommended corrective action has been done. The use of inspection report forms will save time, maintain uniformity in the record-keeping, and provide a "check-list" to reduce the chance of overlooking important roof components during the inspection.

In addition to regular inspection reports, a record of ANY work performed on the roof should be included in the historical file--not just roofing repair. Often repair work by electrical and/or mechanical trades on roof-mounted equipment may cause damage to the roof. Also, installations of antennas, guy wire anchors, or other equipment on the roof should be inspected and recorded.

Photographs are valuable visual records and should be used to accompany and supplement the inspection reports. Cameras which provide "instantaneous developing" of film are recommended, as they give immediate results and involve lower initial cost. Other cameras may be used where clarity of detail, enlargements, slides or multiple copies of prints are desired.

INSPECTION EQUIPMENT

The following tools and equipment are recommended for roof inspections:

1. Clip board, paper, report forms, ruler, pencils, etc.
2. Sturdy extension ladder
3. Satchel, tool box, or back-pack
4. Flashlight (in working order)
5. Utility knife or roofer's knife, with blades

6. Measuring tape
7. Screwdriver, pliers, claw-hammer
8. Spud bar or coal chisel
9. Whisk broom and wire brush
10. Rope and gloves ($\frac{1}{4}$" nylon rope, leather gloves)
11. Paint spray can
12. Dry rags, mineral spirits (for clean up)
13. Moisture meter
14. Heat gun (non-contact infared thermometer)
15. Camera and film

SAFETY

Extreme caution must be exercised when working on roofs, and inspectors should insist upon good safety procedures by ALL workmen involved in the roofing operations. Ladders should be sturdy, firmly set at base, and securely tied off at the top. Materials and equipment should be hoisted up--NOT carried up the ladder.

Hot bitumen is hazardous for burn injury, as well as a potential for fire. Kettles, and hoisting or pumping equipment should be checked regularly with the manufacturer's instructions, and hand tools must be used and stored properly.

Wind and/or wet conditions increase hazards when working close to the edge of roofs, and may require safety lines. After severe storms, be alert for possible electrical lines. Never step backwards without looking first. Exercise care when working around sheet metal, as loose edges and corners are sharp, Roofing nails are often spilled, or left lying on the roof; they could cause personal injury, or damage to the

membrane, Insist upon good housekeeping.

Another common danger is the possibility of tools, equipment, or materials falling off the roof, or being blown off by the wind. Also, care must be given to the disposal of trash and debris caused by the roofing operations. Enclosed trash chutes or enclosed containers should be used for trash removal.

ROOF SYSTEM COMPONENTS

The basic components of a built-up roof system (BURS) are: (1) the membrane, (2) flashings, and (3) drainage system.

1. Membrane.

Membranes are built up of several layers (or plies) of roofing felt set in hot bitumen. The bitumen provides the waterproofing seal, while the felt reinforces the membrane for strength. The surface is usually covered with aggregates (gravel, cinders or crushed rocks) to protect the membrane from the drying rays of the sun, and from puncture.

Bitumens are made from either asphalt or pitch. Asphalt is a petroleum product from crude oil refineries; pitch is a by-product of coal tar, usually derived from the coking of steel mills. Although asphalt and pitch are both excellent materials, they should never be mixed.

Since both asphalt and pitch look alike, the following simple and reliable test can be used to tell them apart.

Place a sample of bitumen (in small pieces) into a cup of solvent (gasoline, kerosine or mineral spirits) and shake or stir the mixture for about one minute. If the solvent turns black and

non-transparent, the bitumen is asphalt; if the solvent turns slightly yellow or yellow-green and is transparent, the bitumen is pitch. Felts are flexible roll sheets that have been saturated in bitumen (asphalt or pitch). It is necessary to use asphalt saturated felts with asphalt bitumen in the membrane, or pitch saturated felts with pitch bitumen. There are three basic types of felt: organic, asbestos, and glass fiber.

(a) Organic felts are made of wood fibers, waste paper, and old rags.

(b) Asbestos felts are made of asbestos fibers, with some organic fibers.

(c) Glass felts are made of interwoven strands of glass fibers and resemble screen.

Cements used in roofing work are roofing cement and flashing cement. Roofing cements flow more easily, and are used with membrane repairs. These may have asphalt or coal tar base, and must be compatible with the membrane bitumen. Some "wet patch" asphalt roofing cements can be used to make repairs even when surfaces are wet, and coal tar base roofing cement is not available.

Flashing cements are stiffer, and will stay in place even on walls. Only asphalt-based flashing cements are available, but they can be used with all flashing. Flashing cements can also be used for asphalt-based membrane repair if roofing cement is not available.

Primers are asphalt - or coal tar - base bitumens that are thinned with solvent. Primers are required to make the thicker

cements adhere to metal, concrete, masonry or other smooth or nonabsorbent surfaces. Asphalt-base primers are used with asphalt cements, and coal tar-base primers are used with coal tar cements.

2. Flashings.

Flashings are used where the built-up membrane terminates, or is interrupted. This occurs at the edge of the roof, where roof meets a wall or chimney, at expansion joints, or wherever pipes or other mechanical devices penetrate the roof. Flashings may be a continuation of the membrane up a wall or curb (called "base flashing"), or it may involve metal or other material. Some of the basic types of flashing are described in the following.

(a) "Gravel stops" are metal strips with a vertical lip used around the open edges of a built up roof. The purpose is to terminate and anchor the membrane, and to contain the loose gravel on the surface. (See Figure 1).

(b) "Base flashing" is a continuation of the membrane up a short distance on a wall, chimney, parapet or curb. Since roofing felt will crack if bent at 90 degrees, a 45 degree bevel strip (called a cant-strip) is used where roof surfaces abut a vertical wall. This cant strip reduces the angle, and allows the membrane to turn up the wall. Gravel is only used over the horizontal membrane, so a special protective type felt is used as a top layer over the base flashing. (See Figure 2).

(c) "Counterflashing" is a metal strip embedded in the masonry above base flashing, and bent down over the top of the base flashing to prevent water penetration behind

it. (See Figure 2).

(d) "Copings" are metal pieces placed on top of walls to cover the wall and any base flashing on the wall. (See Figure 3).

(e) "Vent flashings" are used to cover the tops of plumbing vents protruding above the roof surface. These are usually sheet lead "boots", having a vertical cylinder seamed to a flat flange at the bottom. The flange is set in mastic (roofing cement), and the membrane is mopped over the flange. The top of the cylinder, or "boot", is turned down inside the pipe. (See Figure 4).

(f) "Pitch pans" are used to seal around pipes, antenna guy anchors, or other roof mounted equipment. They are open metal boxes with flat flange around the base. The box is placed around the pipe, anchor or other equipment to be sealed. The flange is set in mastic, and the membrane is mopped over the flange. The inside of the box is filled with hot asphalt or pitch. (See Figure 5).

(g) "Thru-wall flashing" is a sheet metal flashing used to prevent water penetration into a masonry wall. It may be located just below a stone or concrete coping (which is not waterproof), or it may be located within the wall itself. (See Figure 9).

(h) "Expansion joint" is a structural separation between two building elements designed to allow expansion or contraction movement without causing undue stresses on the building components. Where expansion joints occur in

the roof, some flexible connection is requires to prevent water penetration. (See Figure 10).

NOTE: When expansion joints are not provided at points of movement between building elements, the stresses that occur are likely to tear through the membrane.

3. Drainage System.

The drainage system conducts water from the roof surface. It may simply spill the water over the edge or through "scuppers", or it may contain the water in "gutters" and "downspouts" down to the ground. Also, "roof drains" may be located at low points in flat roof surfaces to allow water to flow through pipes into storm sewers.

(a) "Roof drains" are plumbing pipes which terminate at the roof surface with a metal flange embedded in the roof membrane. It is covered with a metal strainer to prevent clogging.

(b) "Scuppers" are simply holes in the parapet wall to allow water to flow off the roof. The holes are lined with metal, tile or plastic sleeves to prevent water from penetrating into the walls.

(c) "Gutters" are horizontal sheet metal troughs which collect water running over the edge of a roof. These slope slightly to drain into a vertical sheet metal pipe, called a "downspout" (or "lender"). The bottom end of the downspout usually turns outward to discharge the rainwater onto a"splash block", or other suitable surface, to prevent washing out of the soil. (See Figure 6).

INSTALLATION INSPECTIONS

Quality control inspections should be performed by competent personnel on a full-time basis throughout the initial installation of roofing and the re-roofing or major repair of existing roofing. Inspectors should be thoroughly familiar with the building roof plan, the materials and methods specified, the quality of workmanship expected, and all details of the deck, flashings, drainage, insulation, etc. The following procedures are recommended.

1. Pre-Construction Conference.

   The inspector should meet with the roofing contractor and his foreman prior to beginning any roofing operations. The purpose of the meeting is to clearly establish what is to be expected during the performance of the contract. This will avoid misunderstandings later, and help establish an efficient organization of the work. The following points should be covered.

   (a) The ground area adjacent to the building to be utilized by the roofing contractor for his operations. This should be adequate in size for the scope of the work, but should not unduly encumber more area than is actually needed. Public safety must be a prime consideration in locating the work area.

   (b) Location of storing materials on the site, and the proper protection of these materials. Roofing felts must be protected from the weather, and should be raised above the ground. Covering with plastic sheeting is NOT considered adequate, as condensation forms on the underside of the plastic each evening.

(c) Protection of the owner's property must be provided. Heating kettles are a severe cause of damage, from both the temperature and leakage of hot bitumen. The handling of hot bitumen also involves leakage. Ground cover protection (such as plywood) should be required under kettles, and canvas or plastic covering over bushes and shrubs where leakage is likely to occur. Kettle locations should be moved from time to time, as prolonged cover in one spot will kill grass.

(d) Safety is a MAJOR factor in any roofing operation. The inspector must require an effective safety program that will protect the general public as well as the workmen.

(e) Proper handling of materials to the roof should be established. Hoisting equipment or cranes require consideration before operations begin, as they involve both SAFETY and PROPERTY PROTECTION.

(f) Proper disposal of trash and debris should be agreed upon. All roofing operations involve waste materials; re-roofing or major repair generally involve removal of old roofing, insulation and gravel. How these materials are to disposed of must be a prime concern. Good housekeeping should be required throughout the operation.

(g) Sanitary facilities must be provided. If the roofing contractor is to furnish a portable toilet(s), it (they) should be properly located within the work area. If owner's facilities are utilized, then appropriate rules should be established for workmen so that they do not disrupt the normal use by occupants of the building.

(h) Finally, all materials and methods specifications should be thoroughly understood. Any changes from those specifications MUST BE APPROVED IN WRITING by proper authorities. All roof bonds, or warranty periods, should be clearly established.

2. Inspection of Roof Deck

Before any roofing is applied, the roof deck should be thoroughly inspected for suitability. The type of deck system will determine the type of insulation, the method of securing base sheets, and other factors. All decks should be smooth and thoroughly dry (no more than 10% moisture content).

All decks should slope to drain (at least 1/4" per foot). This slope should, preferably, be designed into the structure, but it may be accomplished by tapered thickness of the insulation. If proper slope is not provided, notify the designer IN WRITING.

Expansion joints should be provided wherever there is a change in deck materials, or a change in deck direction. Even if expansion joints are not required for structural purposes, the roofing system will require such a break at these locations.

Some of the most common types of decks are outlined in the following:

(a) Wood Decks

Although solid boards are seldom used in new construction, they may be encountered in re-roofing or major repairs. The same precautions apply as with plywood. Due to shrinkage, swelling, warping and nail withdrawal, it is NOT recommended that built-up roofing be applied directly over wood decks. Insulation should always be used over wood decks; even if

not required for thermal resistance. Wood decks should be covered with saturated felt NAILED to the deck. (NEVER MOP FELTS DIRECTLY TO THE WOOD.) Next, two layers of insulation board should be applied over the felt, being sure to stagger the joints in the insulation. The first layer of insulation may be nailed, but the second layer should be mopped. Two layers of 1/2" thick insulation are better than one layer 1" thick.

(b) Wood Fibered Decks

These decks use treated wood fibers cemented together into structural panels, usually with tongue-and-groove edges. They offer better thermal insulation than wood, and, since they have some acoustical qualities, are often left exposed as a ceiling on the underside. It is recommended that these decks be treated the same as wood decks (above).

(c) Steel Decks

Steel decks are heavy gauge sheet metal rolled into flat corrugations to provide structural panels. These panels are usually spot-welded (using welding washers) to a steel structural system to provide a platform, over which rigid insulation board is applied to form the roof deck. Several recommendations are offered for these decks, as they account for over half of new construction.

1. Check welds securing the steel deck. Make sure welding washers are used, and that weld spacing conforms to manufacturer's instructions.
2. Check laps in steel decking to insure that they are nesting flat. Any ridges or uneven laps will make application of the insulation uneven.

3. Provide "expansion joints" in the roof membrane wherever the steel deck changes directions. Otherwise, movement in the metal deck can tear the membrane.

4. One layer of rigid insulation is often applied in a mopping of hot bitumen directly over the steel deck. This requires prompt and accurate placement of the insulation panels, as the bitumen cools rapidly on the steel deck. It is recommended that the insulation be applied in TWO LAYERS; the first layer using mechanical fasteners for better up-lift protection, and the second layer being applied with hot-mopped bitumen with all joints being staggered.

(d) Prestressed Concrete Decks

Precast, prestressed concrete decks offer many advantages, and are quite popular. Although technology is improving, there are still major concerns with this deck type.

1. The prestressing process produces a negative deflection, called "camber", which cannot be uniform in all panels. When these cambered panels are placed side-by-side, they produce uneven slabs. This can be minimized by jacking them into alignment, and securing them with "weld plates" embedded in the casting process. Another solution is to provide a cast-in-place topping over the precast slab. However, the most common solution is to merely grout the uneven joints. Where grouting is used, it should be extended over a wide enough area so that the slope between panel joints does not exceed 1/8" per foot.

2. Often precast slabs are left exposed to the weather for long periods before roofing operations begin. They should always be checked for moisture immediately before applying any insulation or roof membrane. They must be DRY (10% or less moisture) before proceeding with roofing.

(e) Cast-in-Place Roof Decks

There are a number of materials used for cast-in-place roof decks: structural concrete, light weight concrete, and gypsum as examples. Since most of these are non-nailable decks (or questionable at best), the membrane base sheet must be hot-mopped to the deck. The presence of ANY moisture means a poor bond, and the liklihood of forming blisters. It is extremely difficult to obtain a DRY condition with any poured-in-place deck. Therefore, a two-layer rigid insulation is recommended over such decks, with roof vents to allow any residual moisture to escape without causing blisters or ridges.

3. Inspection of Membrane Application

Once the roof deck has been approved, the application of the membrane can begin. The inspector should keep a daily log throughout the application process, recording dates, weather conditions, temperatures, number of workmen, as well as all major activities of the crew. Photographs should be taken as visual records of the progress. These become extremely valuable records for future reference.

The application of the membrane should follow the specifications unless written "change orders" modify the procedure. Some of the points of concern for the inspector are outlined in the following.

a. Check all materials against those specified. Any variation, without written approval, should be rejected.

b. Make sure the appropriate number of PLIES (layers) are being installed. This can be determined by measuring the off-set distance from the edge of one roll of felt to the edge of the next roll. This distance (in inches) divided into the width of the roll (usually 36") will give the number of plies being installed. For example, an off-set distance of 9" between rolls, and a 36" roll width would be: 36/9 = 4 plies.

c. Frequently check the temperature of the bitumen. Heating kettles usually have a temperature gauge, and emersion type thermometers can be used in mop buckets on the roof. A much better device, however, is the "heat gun", or hand held infrared thermometer that can be pointed at a nearby surface and indicates the temperature. Bitumen temperature must be carefully controlled:

> Coal tar pitch should never be heated above 425^{O}F, and should be applied above 350^{O}F.
>
> Asphalt should never be heated above 500^{O}F, and should be applied above 375^{O}F.

The EVT (Equiviscous Temperature) of asphalt bitumen is a new concept based upon the fact that asphalts from different sources will have different viscosities at the same temperatures. The EVT is the temperature of an asphalt when it reaches a target viscosity of 125 centistokes. Asphalts with EVT temperature labels are available, and the temperature at the point of application should be the EVT temperature plus or minus 25^{0} Fahrenheit.

d. Felts should be rolled out in a straight line. Any change in direction causes the felt to buckle -- called "fishmouthing". Felts should be rolled out into a solid bed of hot-mopped bitumen so that even the edges are completely sealed. Felts should be broomed smooth to eliminate any air pockets.

e. Moisture readings should be periodically taken if a moisture meter is available. The presence of moisture in the deck or in the felts may reduce the bond, and produce blisters.

f. Gravel aggregates should be embedded in a "flood coat" of hot bitumen -- where bitumen is poured out rather than being mopped on.

g. When roofing work is terminated at the end of the day without the application of gravel, the completed felts should be given a "glaze coat" -- hot bitumen mopped over the surface to prevent absorption in the felts.

4. Inspection of Flashings and Drainage

Since flashing and drainage components account for a large per centage of roofing failures, it is necessary to inspect these details with utmost care. See Figures one through ten, and "Roof Installation Inspection Report Form" in the Appendix. A few common problems should be emphasized.

a. Flanges of gravel stops, vent flashings, pitch pans, roof drains and expansion joints must be securely fastened to avoid movement or up-lift; and these flanges must be well sealed by the membrane (or strip mopping) over the flange.

b. Lap splices must provide sufficient overlap, and must be properly sealed.

c. Dissimilar metals in contact with each other in the presence of moisture will produce electrolysis, or "galvanic corrosion", in which one metal will disintegrate. To avoid this, the metals must be separated, or insulated from each other.

d. All exposed ferrous metals should be protected by a coating of rust-inhibitive paint to provide longer life and avoid rust staining.

MAINTENANCE INSPECTIONS

Maintenance is essential to any roofing system, but particularly to built-up roofing systems. Periodic inspections are the key element in a good maintenance program. At least two (2) maintenance inspections should be made each year, preferably each Spring and Fall.

In addition, special inspections should be made after severe storms, and whenever ANY work is performed on the roof. Keep all unauthorized persons off the roof.

Maintenance of roofing systems is primarily a matter of GOOD HOUSEKEEPING and rountine PREVENTIVE MAINTENANCE. Removing trash, leaves and liter from roof surfaces, painting of ferrous metals, cleaning out roof drainage systems, and close attention to details that may give warnings of deterioration are all part of the continuing process.

A special "ROOF MAINTENANCE MANUAL" for built-up roof systems has been prepared as a companion to this manual, and should be referred to for maintenance, trouble-shooting, and minor repairs. See also the "Semiannual Roof Inspection Report Form" in Appendix for inspection details.

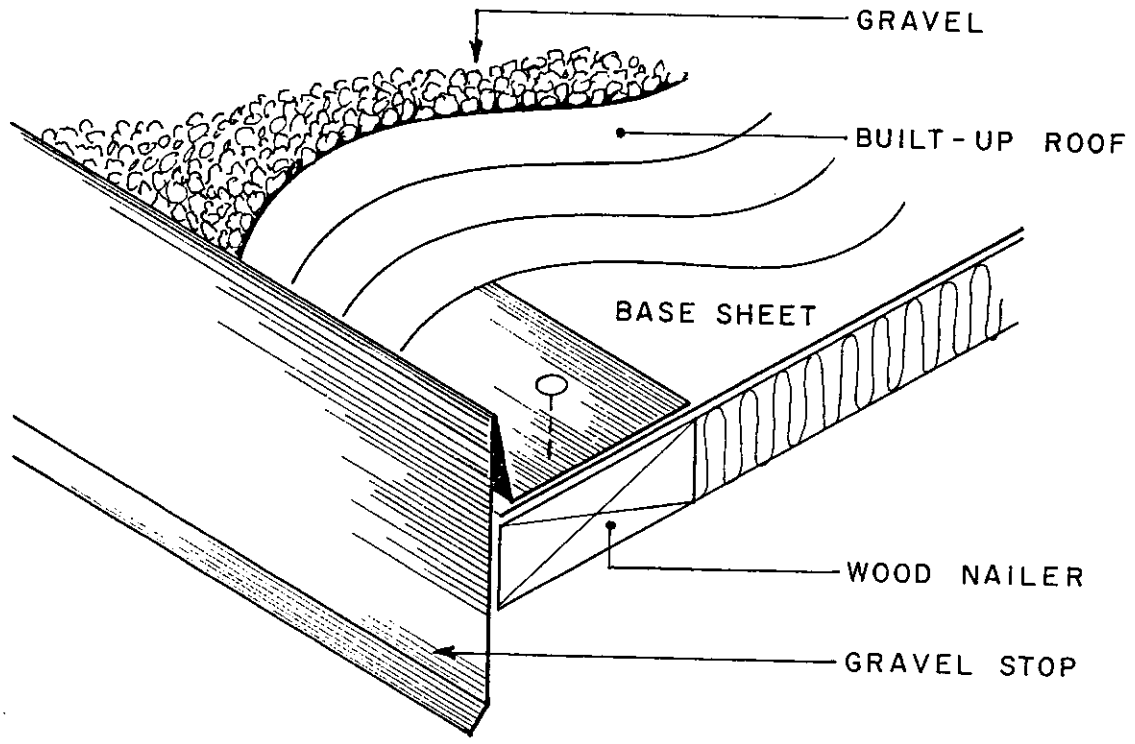


FIG. 1 GRAVEL STOP

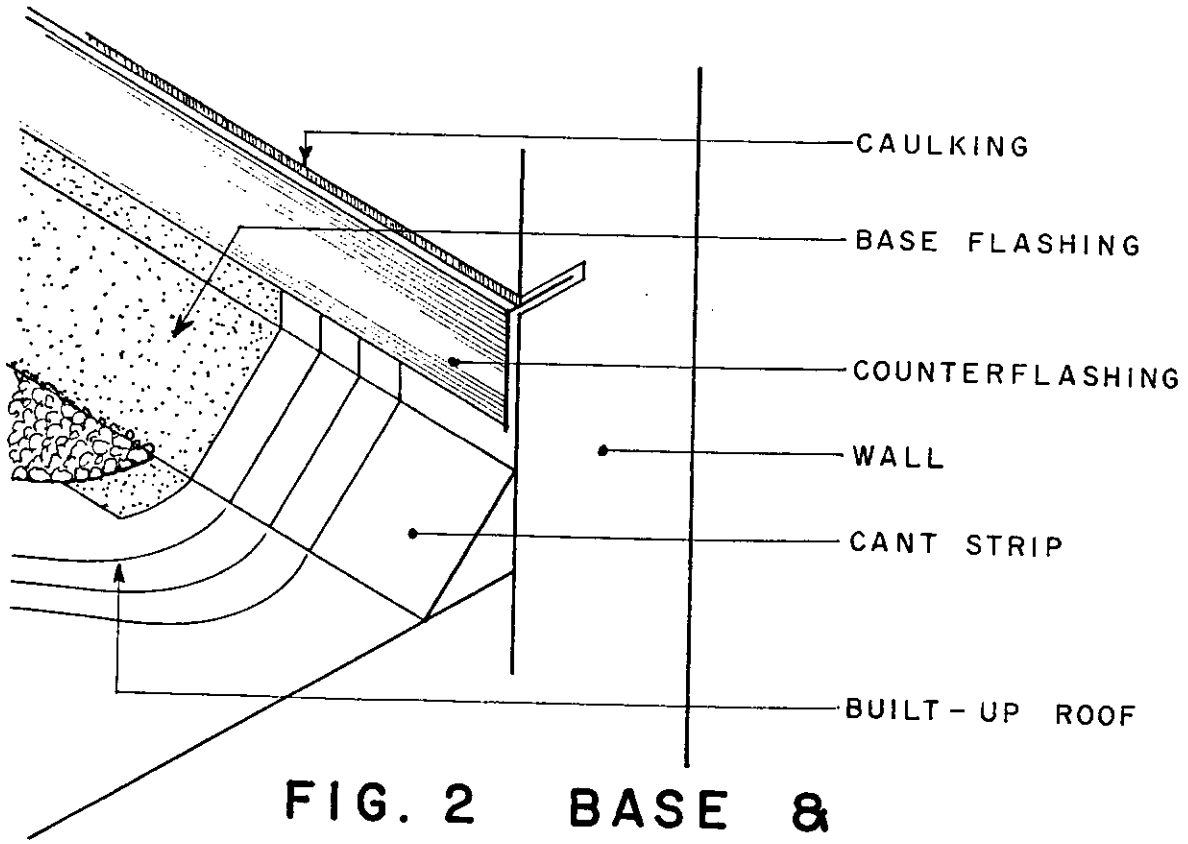
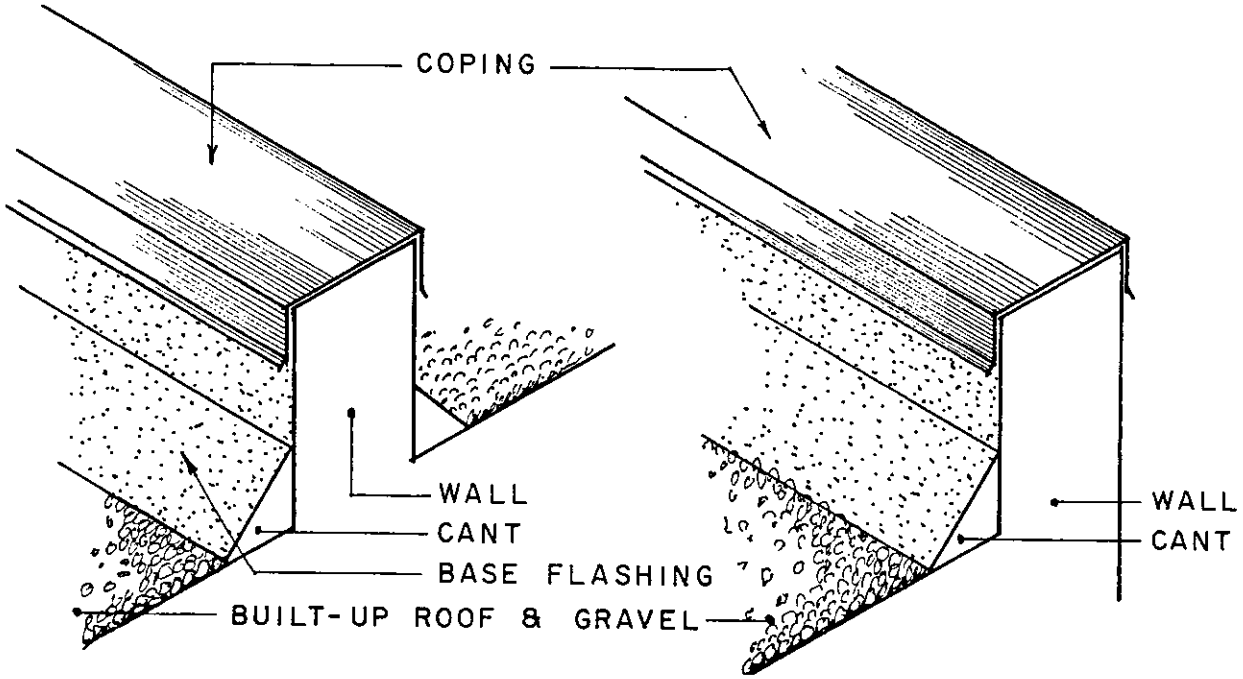


FIG. 2 BASE & COUNTERFLASHING



(A) ROOF BOTH SIDES

(B) ROOF ONE SIDE

FIG. 3 COPING

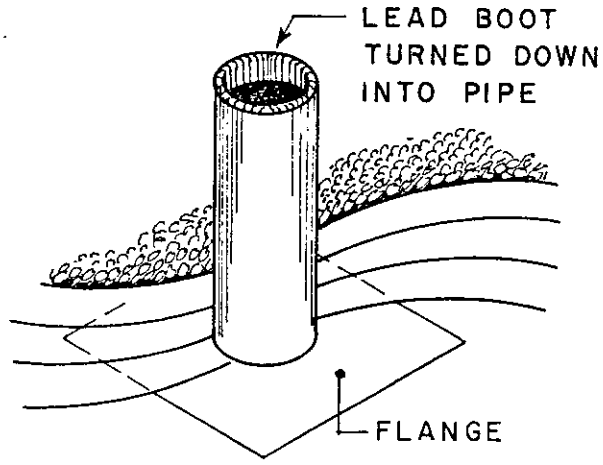


FIG. 4
VENT FLASHING

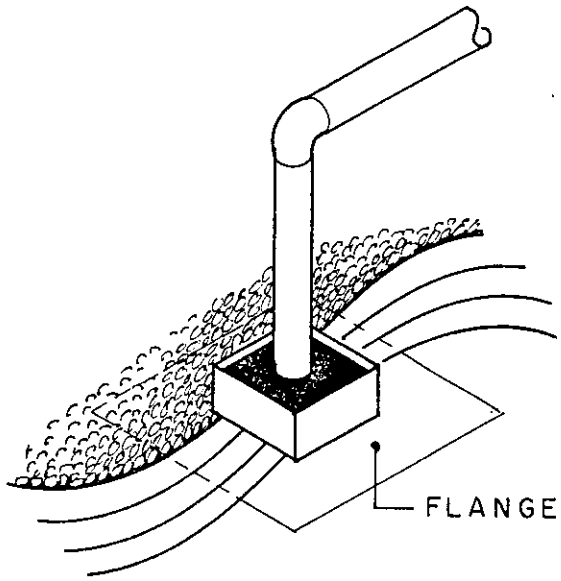


FIG. 5
PITCH PAN

8. Record of any changes made to or on roof surfaces, including mechanical or electrical installations, antenna repair work, etc.
9. Reports of any problems and corrective action taken.
10. Record of all maintenance work done.

INSPECTIONS

The key to a proper roof maintenance program is the adoption of a periodic inspection system. Regular inspection of the roof should be made by competent personnel at least twice each year, preferably each spring and fall. In addition, an inspection should be made after exposure of the roof to unusually severe weather conditions or other hazards. Maintenance personnel can be trained to make inspections, using the inspection checklist provided.

During inspection, every component of the roofing system must be closely checked. Any signs of deterioration should be noted, together with corrective action to be taken. When the corrective work has been performed, this is noted and dated to provide historical record. Photographs can provide valuable visual records.

The use of inspection report forms will save time, maintain uniformity in record keeping, and provide a "check-list" to reduce the chance of over-looking important roof components during the inspection.

HOUSEKEEPING

A fundamental requirement of good roof maintenance is basic care and cleaning. All roof surfaces should be kept free of trash and debris. Trash, such as leaves and paper, can be washed into scuppers, gutters or downspouts and clog up the roof drainage. Cans, bottles,

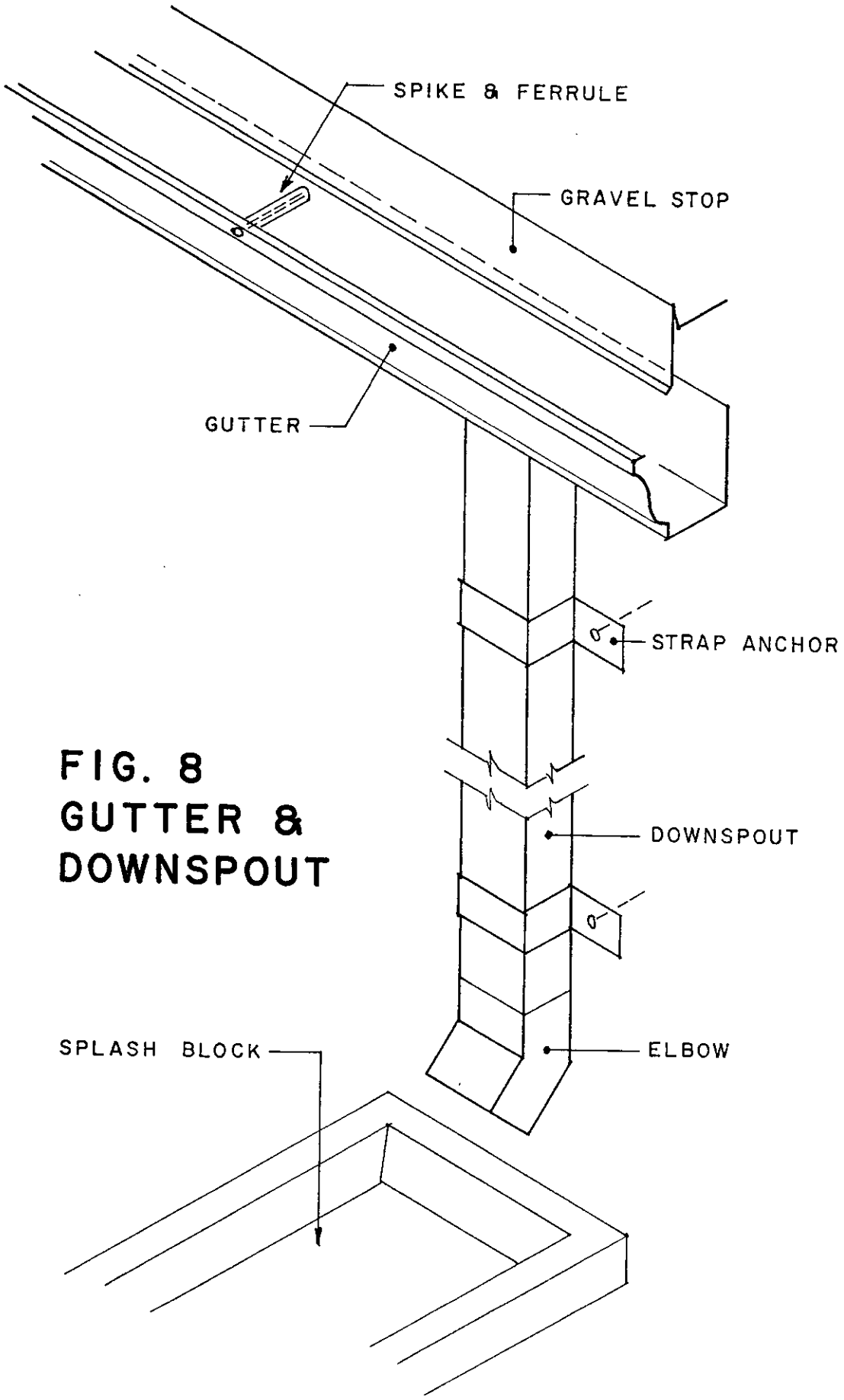


FIG. 8
GUTTER &
DOWNSPOUT

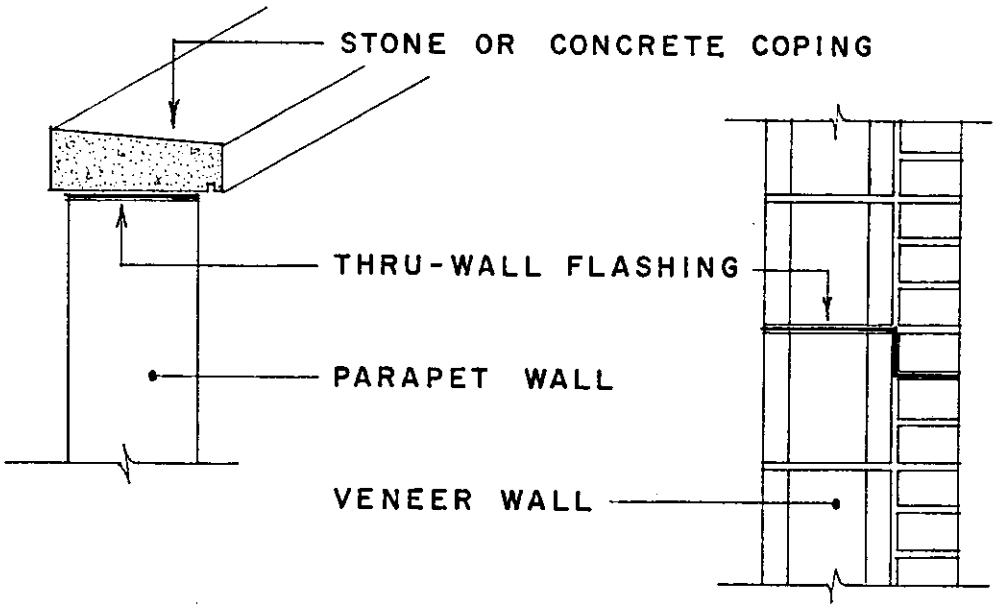


FIG. 9 THRU-WALL FLASHING

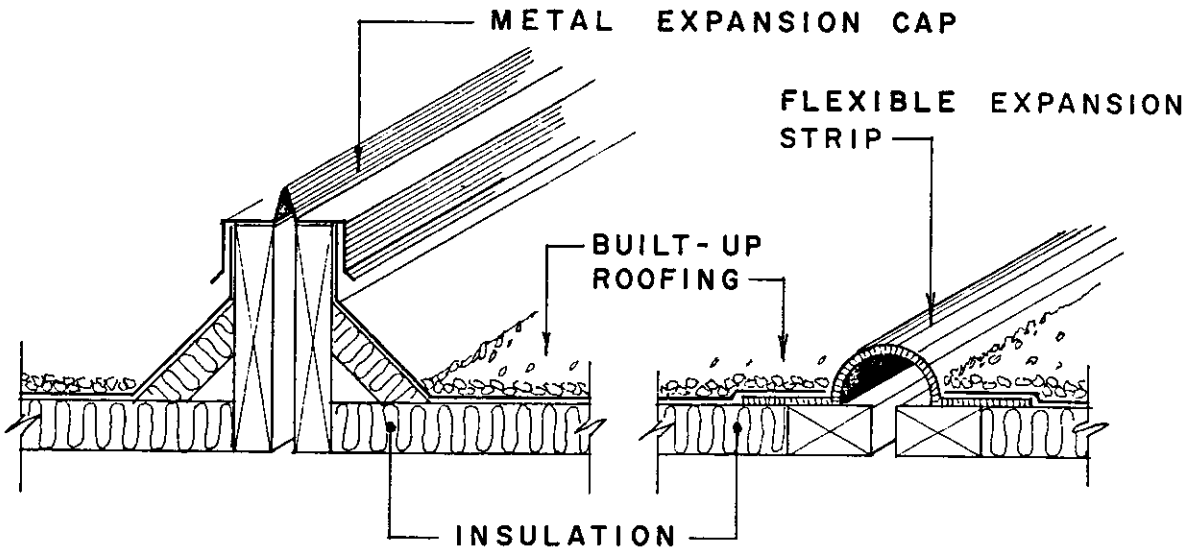


FIG. 10 EXPANSION JOINTS

ROOF INSTALLATION INSPECTION REPORT FORM

Building: _____ Date of Inspection: _____

Location: _____ Inspected by: _____

PRECONSTRUCTION CONFERENCE

Was preconstruction conference held? _____ yes _____ no

A record of the Preconstruction Conference should show date, place, names of persons present, all metters discussed, and any instructions, given. This record should be placed in the job historical file for future reference.

ROOF DECK

1. Type of Deck: _____
2. Type of Insulation: _____
3. Roof Slope (1/4" per foot minimum): _____
4. Surface Condition (smooth, rough, uneven, etc.): _____
   _____
5. Moisture: _____
6. Deck is Acceptable: _____yes _____no
   If no, what corrective action must be taken? _____
   _____
   _____

ROOF MEMBRANE

1. Weather and Temperature: _____
2. Manufacturer of roofing materials used: _____
   _____
   _____
3. Bitumen is: _____Asphalt _____ Coal Tar Pitch

   Temperature of bitumen at point of application? _____°F
4. Type of Felt: _____Organic _____Glass Fiber _____Asbestos

ROOF MEMBRANE (con't)

5. Number of Plies specified? _____

6. Base Sheet Required? ____yes _____no

7. Application of Membrane:
   Felt rolls in straight lines? _____yes _____no
   Rolls fully set in bitumen? _____yes _____no
   Spacing of rolls, edge to edge _____inches
   Felt edges sealed? _____yes _____no
   End laps _____inches
   Number of felt plies installed _____
   Glaze coating applied? _____yes _____no

8. Comments on Membrane: _____
   _____
   _____

GRAVEL SURFACE

1. Type of gravel: _____

2. Size of gravel: _____

3. Gravel well embedded in flood coat of bitumen:_____yes _____No

4. Approximate weight of gravel: _____lbs per 100 sq. ft.

FLASHING

1. Base Flashing:
   Material _____
   Laps well sealed? _____yes _____no
   Flashing well sealed to membrane? _____yes _____no

2. Cant Strip:
   Material _____ Size _____

3. Counterflashing:
   Material _____
   Well anchored in masonry? _____yes _____no
   Well caulked to masonry? _____yes _____no
   Lap joints well sealed? _____yes _____no

FLASHING (con't)

4. Gravel Stops:
   Material _____
   Flange well anchored? _____yes _____no
   Flange sealed by membrane? _____yes _____no
   Lap splices sealed? _____yes _____no

5. Vent Flashing:
   Material _____
   Base flange securely anchored? _____yes _____no
   Base flange sealed by membrane? _____yes _____no
   Tops turned down _____ inches

6. Copings:
   Material _____
   Securely anchored? _____yes _____no
   Method of anchorage _____
   _____

7. Expansion Joints:
   Type of Joint _____
   Materials _____

8. Are any dissimilar metals used together? _____yes _____no

9. Comments on Flashings: _____
   _____
   _____

DRAINAGE SYSTEM

1. Roof Drains:
   Type _____
   Material _____
   Flange well secured? _____yes _____no
   Pipe connection caulked? _____yes _____no
   Flange scaled by membrane? _____yes _____no
   Are they at low points in roof? _____yes _____no

2. Scuppers:
   Material _____ Size _____
   Are they well sealed? _____yes _____no
   Are they at low points? _____yes _____no

DRAINAGE SYSTEM (con't)

3. Gutters:
   Material _____ Size _____
   Type and spacing of anchors _____
   Laps well sealed? _____yes _____no
   Bent or damaged metals? _____yes _____no
   Sloped to drain? _____yes _____no

4. Downspouts:
   Material _____ Size _____
   Type and spacing of anchors _____
   At low points in gutters? _____yes _____no
   Splash block at base? _____yes _____no

5. Maximum Distance of Water Travel: _____feet

6. Comments on Drainage: _____
   _____
   _____

GENERAL HOUSEKEEPING

1. Ground level work area well organized? _____yes _____no

2. Materials stored and protected? _____yes _____no

3. Are grounds free of trash and litter? _____yes _____no

4. Is roof area well organized? _____yes _____no

5. Is there adequate provision for trash removal? ____yes ____no

6. Comments on Housekeeping: _____
   _____
   _____

SAFETY

1. Who is responsible for safety in roofing opeation? (name of person): _____

2. Are safety measures adequate? _____yes _____no
   If no, what actions should be taken? _____
   _____

SEMIANNUAL ROOF INSPECTION REPORT FORM

Building: _____ Date of Inspection: _____

Location: _____ 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:
   _____
   _____

SEMIANNUAL ROOF INSPECTION REPORT FORM
PAGE 2

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 _____

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 litter. 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:

   _____
   _____

APPENDIX V

ROOF MAINTENANCE MANUAL

FOR BUILT-UP ROOF SYSTEMS

SCHOOL OF BUILDING CONSTRUCTION
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CONTENTS

ROOF MAINTENANCE MANUAL

INTRODUCTION

It is estimated that 40 per cent of roof failures are due to inadequate maintenance by owners -- or no maintenance at all. The most important reason for establishing a program of regular roof maintenance is to protect the owner's investment. A properly executed maintenance program will add years to the useful life of the roof, will detect minor problems before damage is widespread, and will avoid annoying interruption of the internal functions of the building.

The purpose of this manual is to provide guidelines for establishing and conducting a roof maintenance program. The best time to plan for roof maintenance is at the time the roof is first installed.

HISTORICAL FILE

A historical record should be maintained for roofs from the time they are installed. Such a record should include:

1. Roof plans and specifications.
2. Contract documents.
3. Name and address of architect, consultant, contractor, and other persons or firms concerned with roof installation.
4. All correspondence or notes between parties involved with roof installation.
5. Bonds or guarantees from material manufacturer and/or roofing contractor.
6. Record of all inspections during roof installation, together with any instructions to roofing contractor.
7. Report of each maintenance inspection, with photos.

8. Record of any changes made to or on roof surfaces, including mechanical or electrical installations, antenna repair work, etc.
9. Reports of any problems and corrective action taken.
10. Record of all maintenance work done.

INSPECTIONS

The key to a proper roof maintenance program is the adoption of a periodic inspection system. Regular inspection of the roof should be made by competent personnel at least twice each year, preferably each spring and fall. In addition, an inspection should be made after exposure of the roof to unusually severe weather conditions or other hazards. Maintenance personnel can be trained to make inspections, using the inspection checklist provided.

During inspection, every component of the roofing system must be closely checked. Any signs of deterioration should be noted, together with corrective action to be taken. When the corrective work has been performed, this is noted and dated to provide historical record. Photographs can provide valuable visual records.

The use of inspection report forms will save time, maintain uniformity in record keeping, and provide a "check-list" to reduce the chance of over-looking important roof components during the inspection.

HOUSEKEEPING

A fundamental requirement of good roof maintenance is basic care and cleaning. All roof surfaces should be kept free of trash and debris. Trash, such as leaves and paper, can be washed into scuppers, gutters or downspouts and clog up the roof drainage. Cans, bottles,

or other debris may be blown across or against roof surfaces with such force as to cut or penetrate the membrane. Trash and debris should be collected in trash bags or boxes. No loose objects should be allowed to remain on the roof.

Painted surfaces on or above the roof should be coated periodically to maintain the protective film. Ferrous metals should be coated with rust-inhibitive paint. Masonry or concrete should be painted with a good masonry paint or silicone sealer. Cracks in masonry or concrete must be sealed with caulking before painting.

Dissimilar metals should not be allowed to be in contact with each other. When two different metals are in close proximity, they should be isolated or insulated with felt membrane, or other similar material. Otherwise, electrolysis (or galvanic corrosion) may disintegrate the weaker metal.

DO NOT ALLOW UNAUTHORIZED PERSONS ON THE ROOF.

SAFETY

Extreme caution must be exercised when working on roofs. Where possible, two men should work together. Check ladders carefully before each use. Bottom of ladder should be firmly set, with top tied off to prevent slipping. Tools, equipment and materials should be hoisted to the roof by rope, rather than being carried up the ladder.

Wind and/or wet conditions increase hazards when working close to the edge of roofs, and may require safety lines. After severe weather, be alert for possible electrical lines. Never step backwards without looking first. Exercise care when working around sheet metal, as loose edges or corners are sharp.

ROOF SYSTEMS COMPONENTS

The basic components of a built-up roof system (BURS) are: (1) the membrane, (2) flashings, and (3) drainage system.

1. Membrane.

Membranes are built up of several layers (or piles) of roofing felt set into hot bitumen. The bitumen provides the waterproofing seal, while the felt reinforces the membrane for strength. The surface is usually covered with aggregates (gravel, cinders or crushed rocks) to protect the membrane from the drying of the sun, and from puncture.

Bitumens are made from either asphalt or pitch. Asphalt is a petroleum product from crude oil refineries; pitch is a by-product of coal tar, usually derived from the coking of steel mills. Although asphalt and pitch are both excellent materials, they should never be mixed.

Since both asphalt and pitch look alike, the following simple and reliable test can be used to tell them apart.

Place a sample of bitumen (in small pieces) into a cup of solvent (gasoline, kerosine or mineral spirits), and shake or stir the mixture for about one minute. If the solvent turns black and non-transparent, the bitumen is asphalt; if the solvent turns slightly yellow or yellow-green and is transparent, the bitumen is pitch.

Felts are flexible roll sheets that have been saturated in bitumen (asphalt or pitch). It is necessary to use asphalt saturated felts with asphalt bitumen in the membrane, or pitch saturated felts with pitch bitumen. There are three basic types of

felt: organic, asbestos, and glass fiber.

(a) Organic felts are made of wood fibers, waste paper, and old rags.

(b) Asbestos felts are made of asbestos fibers, with some organic fibers.

(c) Glass felts are made of interwoven strands of glass fibers and resemble screen.

Cements used in roofing are roofing cement and flashing cement. Roofing cements flow more easily, and are used with membrane repairs. These may have asphalt or coal tar base, and must be compatible with the membrane bitumen. Some "wet patch" asphalt roofing cements can be used to make repairs even when surfaces are wet, and coal tar base roofing cements can also be used in wet locations.

Flashing cements are stiffer, and will stay in place even on walls. Only asphalt based flashing cements are available, but they can be used with all flashing. Flashing cements can be used for asphalt-based membrane repair if roofing cement is not available.

Primers are asphalt - or coal tar - base bitumen that are thinned with solvent. Primers are required to make the thicker cements adhere to metal, concrete, masonry or other smooth or nonabsorbent surfaces. Asphalt-base primers are used with asphalt cements, and coal tar-base primers are used with coal tar cements.

2. Flashings.

Flashings are used where the build-up membrane terminates, or is interrupted. This occurs at the edge of the roof, where the roof meets a wall or chimney, at expansion joints, or wherever

pipes or other mechanical devices penetrate the roof. Flashings may be a continuation of the membrane up a wall or curb (called "base flashing"), or it may involve metal or other material. Some of the basic types of flashing are described in the following:

(a) "Gravel stops" are metal strips with a vertical lip used around the open edges of a built up roof. The purpose is to terminate and anchor the membrane, and to contain the loose gravel on the surface. (See Figure 1).

(b) "Base flashing" is a continuation of the membrane up a short distance on a wall, chimney, parapet or curb. Since roofing felt will crack if bent at 90 degrees, a 45 degree bevel strip (called a "cant strip") is used where roof surfaces abut a vertical wall. This cant strip reduces the angle, and allows the membrane to turn on up the wall. Gravel is only used over the horizontal membrane, so a special protective type is used as top layer over the base flashing. (See Figure 2).

(c) "Counterflashing" is a metal strip embedded in the masonry above base flashing, and bent down over the top of the base flashing to prevent water penetration behind it. (See Figure 2).

(d) "Copings" are metal pieces placed on top of walls to cover the wall and any base flashing on the wall. (See Figure 3).

(e) "Vent flashings" are used to cover the tops of plumbing vents protruding above the roof surface. These are usually sheet lead "boots", having a vertical cylinder

seamed to a flat flange at the bottom. The flange is set in mastic (roofing cement), and the membrane is mopped over the flange. The top of the cylinder, or "boot", is turned down inside the pipe. (See Figure 4).

(f) "Pitch pans" are used to seal around pipes, antenna guy anchors, or other roof mounted equipment. They are open metal boxes with flat flange around the base. The box is placed around the pipe, anchor or other equipment to be sealed. The flange is set in mastic, and the membrane is mopped over the flange. Inside the box is filled with hot asphalt or pitch. (See Figure 5).

(g) "Thru-wall flashing" is a sheet metal flashing used to prevent water penetration into a masonry wall. It may be located just below a stone or concrete coping (which is not waterproof), or it may be located within the wall itself. (See Figure 9).

(h) "Expansion joint" is a structural separation between two building elements designed to allow expansion or contraction movement without causing undue stresses on the building components. Where expansion joints occur in the roof, some flexible connection is required to prevent water penetration. (See Figure 10).

Note: When expansion joints are not provided at points of movement between building elements, the stresses that occur are likely to tear through the membrane.

3. Drainage System.

The drainage system conducts water from the roof surface. It may simply spill the water over the edge or through "scuppers", or it may contain the water in "gutters" and "downspouts" down to the ground. Also, "roof drains" may be located at low points in flat roof surfaces to allow water to flow through pipes into storm sewers.

(a) "Roof drains" are plumbing pipes which terminate at the roof surface with a metal flange embedded in the roof membrane. It is covered with a metal strainer to prevent clogging. (See Figure 6).

(b) "Scuppers" are simply holes in the parapet wall to allow water to flow off the roof. The holes are lined with metal, tile or plastic sleeves to prevent water from penetrating into the walls. (See Figure 7).

(c) "Gutters" are horizontal sheet metal troughs which collect water running over the edge of a roof. These slope slightly to drain into a vertical sheet metal pipe, called a "downspout" or "leader". The bottom end of the downspout usually turns outward to discharge the rainwater onto a "splash block" or other suitable surface, to prevent washing out of the soil. (See Figure 8).

REPAIRS (Classification)

Roof repairs fall into three categories: (1) Minor repairs; (2) Major repairs, and (3) Emergency repairs.

1. Minor Repairs.

Minor repairs are those involving small roof areas which can be satisfactorily accomplished using COLD methods, and which do not require the technical skill of a roofer. These repairs should be undertaken only when the surface is clean and DRY.

2. Major Repairs.

Major repairs are those involving larger roof areas, those requiring HOT methods, the replacement of a substantial amount of material, or require the technical skill of a roofer. Major repairs should not be undertaken by the maintenance personnel.

3. Emergency Repairs.

Emergency repairs are those made quickly to prevent water damage to building contents until permanent repairs can be made. They are usually temporary repairs, often made under adverse weather conditions. The best time to prepare for emergency repairs is before they are required. To save time in an emergency, basic tools and materials should be stored in one easily accessible place. The following are suggested as minimum.

Suggested Tools and Equipment

a. Sturdy extension ladder.
b. Satchel or tool box.
c. Straight-claw hammer, mason's hammer.
d. Tinsnips, pop riveter and rivets.
e. Screwdriver and sheet metal screws.
f. Flashlight (in good working order).
g. Utility knife or roofer's knife, with blades.
h. Measuring tape.
i. Spud bar or coal chisel.
j. Trowels (square and pointed) for mastic.
k. Square-ended shovel.
l. Whisk broom and push broom.
m. Caulking gun and tubes of caulking (butyl or silicone).
n. Rope and gloves.
o. Paint brush, for primer.

Suggested Tools and Equipment (con't)

p. Wire brush.
q. Pliers (regular and wire-cutting) and adjustable wrench.
r. Dry rags.
s. Paint spray can (for marking roof leak areas).

Suggested Materials

a. Roofing cement ("wet-patch" type).
b. Primer.
c. Roofing felt, 1 roll #15.
d. Mineral-surfaced saturated felt, 1 roll 90#, white.
e. Roofing nails and aluminum nails.
f. Flashing cement (asphalt-based is only type).
g. Polyethylene plastic sheeting, 1 roll, six-mil thickness.
h. Mineral spirits, 1 gallon (for clean up).
i. Roof aggregate -- gravel of same type used on roof.
j. Special leak-plugging chemicals, such as expanding bentonite, might also be considered.

REPAIR PROCEDURES (Trouble Shooting)

Since roof repair procedures vary with the type of defect to be remedied, the most common roofing defects are (a) identified, (b) probable causes listed, and (c) corrective procedure given. Note that not all repair procedures should be undertaken by maintenance personnel. All "major" repairs should be performed by a competent roofing contractor. During the warranty period ALL ROOF REPAIR should be referred to the contractor who installed the roofing.

MEMBRANE DEFECTS

1. Bare Spots.

   (a) Bare spots are areas of the membrane not completely covered by aggregate (gravel). This leaves the bitumen exposed to puncture injury and the drying rays of the sun. The result is rapid deterioration of membrane.

   (b) It may be caused by insufficient aggregate in the

installation, by inadequate adhesion of aggregate into the "flood coat" of bitumen, or the loss of aggregate by wind or water.

(c) The best remedy is to have a roofing contractor apply a primer and flood coat of hot bitumen, and embed aggregate into this flood coat to cover the bare spot. As an alternate, clean bare spot surface thoroughly, apply cold-process recoating/resaturant, and embed gravel to cover area. Even loose gravel is better than none at all.

2. Alligatoring -- cracking of bitumen.

(a) Where thick coats of bitumen are exposed, the surface shrinks and cracks appear in both directions, somewhat resembling an alligator's hide. These cracks can eventually become deep enough to cause tension cracks in the felts.

(b) This condition may result if the application of the flood coat of bitumen is too thick, but more frequently it is due to the flowing of bitumen to low spots in the roof during extremely hot weather.

(c) To correct severe alligatoring it is necessary to chip off the "blobs" of thick bitumen, and clean the surface. Then apply a thin coat of primer, and allow to dry. Next, apply an emulsion, and embed a glass fiber fabric into the wet emulsion. Add more emulsion, and cover with gravel.

Note: DO NOT add additional hot bitumen over an alligatored roof surface. This simply increases the thermal contraction, and cracking becomes more severe.

3. Blisters.

(a) Blisters are soft, spongy bubbles in the membrane. They may be small, localized areas, or they may become longer, higher ridges. All blisters will be somewhat larger in hot weather -- smaller in cold temperature.

(b) Blisters are caused by air and moisture being entrapped between layers of felt, or between the membrane and the deck or insulation. As the temperature rises, the air expands and the blister becomes larger. If the blisters rise high enough, the gravel coverage will be lost, and the felt and bitumen will be exposed. If allowed to deteriorate, the membrane will crack and split.

(c) Small blisters that do not expose the membrane should not be disturbed. Unbroken blisters do not leak. DO NOT step on or puncture blisters. Record size and location of blisters on inspection reports so growth or enlargement can be detected.

If blisters expose membrane to deterioration, or if blisters are punctured, they may become a source of leakage. In this event, they should be repaired. The best way to repair blisters is to have a roofing contractor remove them and make a HOT process patch.

A COLD process repair procedure is to chip away the aggregate for at least 12" around the perimeter of the

corrected before durable repairs can be made. Such defects need immediate attention because they can leak a great deal of water in a short time.

(b) The cause of cracks in membranes may be as simple as insulation panels not secured to the roof deck, the lack of allowance for expansion and contraction, or differential movement in the structure itself. If the cause of such cracks cannot be readily determined, a roofing expert should be consulted.

(c) The correction of such a problem is probably a "major" repair, and a roofing contractor should be utilized. This is because it often requires removal of a substantial amount of material to detect and/or correct the cause, and the repairs require HOT process methods and technical skill. It often requires the installation of an expansion joint. As a temporary "emergency" repair, cracks can be sealed with "wet-patch" roofing cement, which should be mounded to cause water to flow away from the crack.

5. Ridges, Wrinkling and Buckling in Membrane.

(a) Long, narrow ridges, or wrinkles, may occur in the felts of the membrane. The tops of the ridges may loose the gravel surface protection, and deteriorate. Continued flexing may result in fatigue or "wrinkle-cracks". Also, ridges may cause ponding in low roof areas.

(b) Cause for wrinkling, or buckling, may be the migration of warm moist air in the attic to the cool roof membrane,

condensing, then being absorbed by organic fibers of the felt. This causes swelling of felt, or wrinkles, usually along the joints in the insulation.

Another cause may be due to poorly attached membrane or insulation shifting because of expansion and contraction. Or it may be due to the warping of insulation panels.

On sloped roofs the cause may be due to slippage of felt plies. In this event the wrinkles occur at right angles to the slope, and near the lower edge of the membrane.

(c) Unless ridges become a problem (such as ponding, deterioration, or "wrinkle-cracks"), they are best left alone. They should be noted on inspection reports, and watched for evidence of deterioration.

In the event of deterioration, they should be coated with roofing mastic and gravel to protect the ridges. If this does not correct the problem, the ridges can be cut, dried out, and covered with multi-ply patch similar to blisters.

6. Fishmouths and Curling Edges in Felt.

(a) A "fishmouth" is a buckle, or wrinkle, along the edge of a felt ply. It resembles a blister, except that one side is open, and may allow water penetration. Fishmouths may rise enough to lose gravel protection.

Sometimes the edges of felt plies curl up and become exposed above the bitumen coating.

(b) Fishmouths are caused whenever a felt roll is moved laterally on the roof before it is fully adhered in bitumen. Or it may result from use of felt with damp edges. Curled felt edges usually occur when the edges of felt rolls are not embedded in bitumen.

(c) If fishmouths or curled edges do not extend back more than two inches, the loose portion may simply be trimmed off and discarded. Where fishmouths extend more than 2" deep, the membrane should be cut down the middle, allowed to dry out inside, then sealed and patched like a blister.

7. Deterioration of Felt or Bitumen.

(a) Both felt and bitumen deteriorate when exposed to sun and weather. They become stiff and brittle, and often show hair-line cracks or pitted surfaces. These are evidence of premature aging.

(b) Deterioration is due primarily to ultra-violet rays of the sun vaporizing the volatile oils in the bitumen. They dry out and gradually lose flexibility and sealing qualities.

(c) All felt and bitumen should be kept covered by gravel. When they show signs of deterioration, their useful life can be extended by applying cold-process recoating/ resaturant materials. All loose gravel should be removed before, and replaced after the application, and roof surfaces must be dry.

FLASHING DEFECTS

1. Base Flashing.

(a) The most common defects in base flashing are puncture, lack of adhesion, and exposure deterioration. Punctures are often small and hard to detect, but they still leak. So close inspection is necessary. Lack of adhesion may take several forms: the vertical laps come open, the base of the flashing may pull away from the membrane, or base flashing sheets may sag or slip. Deterioration may be detected on base flashing by stiff or brittle material, or disintegration of the surface.

(b) Causes for puncture of base flashing range from careless workmen to loose objects blown by the wind. Lack of adhesion defects are not necessarily a reflection on the original installation. Flashing cements are used, and these gradually loose their sealing and adhesive qualities. Deterioration of base flashing is due to its exposed location.

(c) Most punctures of base flashing can be sealed with flashing cement. This does not provide a permanent protection, so sealed punctures should be recorded and checked on each roof inspection. Large punctures may require a patch of new, mineral-surfaced, 90# felt, placed over the damaged area, and set in flashing cement.

Adhesion defects can usually be remedied by applying flashing cement to the loose areas. Again, this is not a permanent seal, so each inspection requires close

attention to all vertical laps, as well as the base connection to the membrane.

When deterioration of the mineral surface on the base flashing is noticed, added life can be afforded by applying a coating of flashing cement. Flashing cement is available with asbestos fibers and aluminum coloring. This is much preferred over the usual black cement, especially for coating the base flashing surface. It can also be used for sealing punctures.

2. Coping and Counterflashing.

   (a) The major problems with metal flashing are damage to the metals, seals at lap splices, loosened fastenings, and caulking where counterflashings enter masonry grooves.

   (b) Causes for damage to the metal may be from expansion and contraction, wind, mechanical injury from workmen, or objects blown against it. Seals at lap splices, as well as loosened fasteners, usually fail due to expansion and contraction or wind. Caulking failure may be due to movement of the metal, due to expansion and contraction, or from a poor bond between the caulking and masonry surface.

   (c) Copings should be carefully inspected for damage, for seals at lap joints, and loosened fasteners. Except for replacement of severely damaged coping, maintenance on coping is largely checking seals and fasteners. When loose, these lap splices and fasteners may be sealed with silicone caulking. Of course, loose fasteners should be

tightened before sealing.

Counterflashing should be checked for seals at lap splices, and caulking. If counterflashing becomes loose in masonry groove, small lead wedges may be driven into the groove to secure it. This should be done before caulking.

3. Vents and Pitch Pans.

(a) An occasional problem with vents and pitch pans is the seal of the flanges by the membrane. A frequent problem with pitch pans is the loss of bitumen seal inside.

(b) A leading cause of loose flanges is the movement of the membrane due to expansion and contraction. While not often a problem the flanges of vents and pitch pans should be carefully checked on each inspection. Also check for damage to the metal. The seal inside pitch pans will gradually lose its flexibility and sealing ability due to loss of volatile oils in bitumen. This is a "must" on the inspection check-list.

(c) When vents are damaged, or flanges become loose, it may require replacement of the lead boot. This replacement is best accomplished by a roofing contractor using HOT process methods.

When necessary, however, it can be done with COLD process application. Chip away the gravel about 18" around the vent. Cut the felt membrane along the perimeter of the flange BUT DO NOT CUT INTO THE BASE SHEET. Carefully remove the old lead boot, and clean the

area from which it was removed. Set the new boot in roofing cement on top of the base sheet, and fasten it securely. Next, build up plies of felt and roofing cement over the flanges to the level of the surrounding membrane. Then cut three layers of felt to fit snugly over the vent boot. The bottom layer should extend 4" beyond the flange; the second layer extends 2" beyond the first; and the third extends 2" beyond the second. Now set each layer successively in roofing cement, and cover the top layer with cement. Then embed gravel over the area, and bend the top of the lead boot down into the vent pipe.

When the bitumen seal in pitch pans becomes stiff, or cracks appear in the surface, it should be replaced. If HOT bitumen is available, the old seal should be removed and replaced. If HOT bitumen is not available, chip out the top portion of the old seal and coat the area with primer. Then fill the pitch pan with roofing cement, providing a slight rise into the center to drain water off the top.

4. Gravel Stops.

(a) The main areas to check on gravel stops are the lap splices, the membrane cover over the flange, and any damages to the metal itself. Sometimes slight bends in the top of a gravel stop will puncture the metal (like the careless handling of a ladder).

(b) The major causes of gravel stop damage are: expansion

and contraction of the metal, wind lifting or bending the metal, and mechanical damage done by careless workmen. Occasionally, deflection of long roof overhangs may cause gravel stops to buckle. The membrane covering the flange of gravel stops must be carefully inspected because heat conducted by the metal often causes premature deterioration of the membrane.

(c) If lap splices are bent or misaligned, they will very likely be a source of leak. Therefore, damaged gravel stops must be straightened and aligned. Punctures of the metal require replacement (which is a major repair requiring a roofing contractor), but small cracks or holes can be sealed with mastic as a temporary emergency repair. Deteriorated membrane covering over gravel stop flanges should be replaced (again, a major repair), but roofing cement may extend the useful life until the major repair can be accomplished.

DRAINAGE SYSTEM DEFECTS

1. Roof Drains.

(a) The major problem with roof drains is clogging. Even when the drain itself does not leak, if stopped up it may cause leaks elsewhere.

(b) Cause of clogging is generally trash and/or debris which falls on, is blown on, or thrown on the roof. Also gravel sometimes washes up around the drain strainer and inhibits flow.

(c) It is recommended that roof drains be FREQUENTLY checked and cleaned.

Note: If roof drains leak, this is a "major" repair. A competent roofing contractor should perform this repair or replacement. If the internal drain pipe leaks, this may require a competent plumbing contractor.

2. Scuppers.

(a) Again, the major problem is clogging. However, another problem to look out for is the seal around the scupper where it passes through the base flashing. Even small pin-holes in this seal can be a major leak because of the volume of water flowing into the scupper.

(b) The cause of clogging is similar to roof drains. The cause of leaks in the seal around scupper is the drying out of the roofing mastic, and sometimes movement of the scupper or base flashing, or both.

(c) Frequently check and clean scuppers to avoid clogging. Each time, carefully check the mastic seal around the scupper. If there is any sign of shrinkage, cracks or holes in the seal, apply a coating of flashing cement.

3. Gutters and Downspouts.

(a) Once again, the major problem is clogging. Another problem to watch out for is the loosening of anchors holding the gutters and downspouts in place. Also check the lap joints for leakage.

(b) The cause of clogging is the same as roof drains and scuppers. The cause of loose anchors and lap joints is

usually the movement due to expansion and contraction of the metal.

(c) Frequently check and clean gutters and downspouts to insure open, free flow of drainage. Also check spikes and ferrules, strap anchors, and other fasteners. Tighten or replace as required to hold these elements securely in place. Check lap joints in gutters for leaks. Apply silicone caulking on inside of gutter, and smooth surface to avoid ridges.

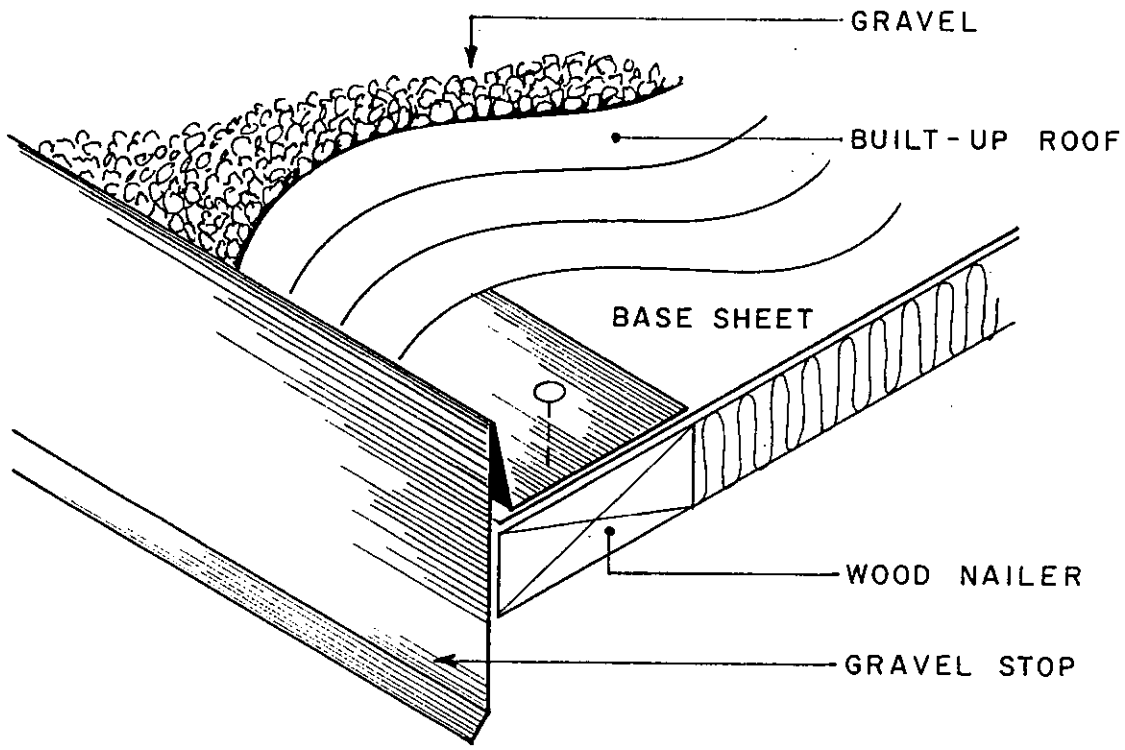


FIG. 1 GRAVEL STOP

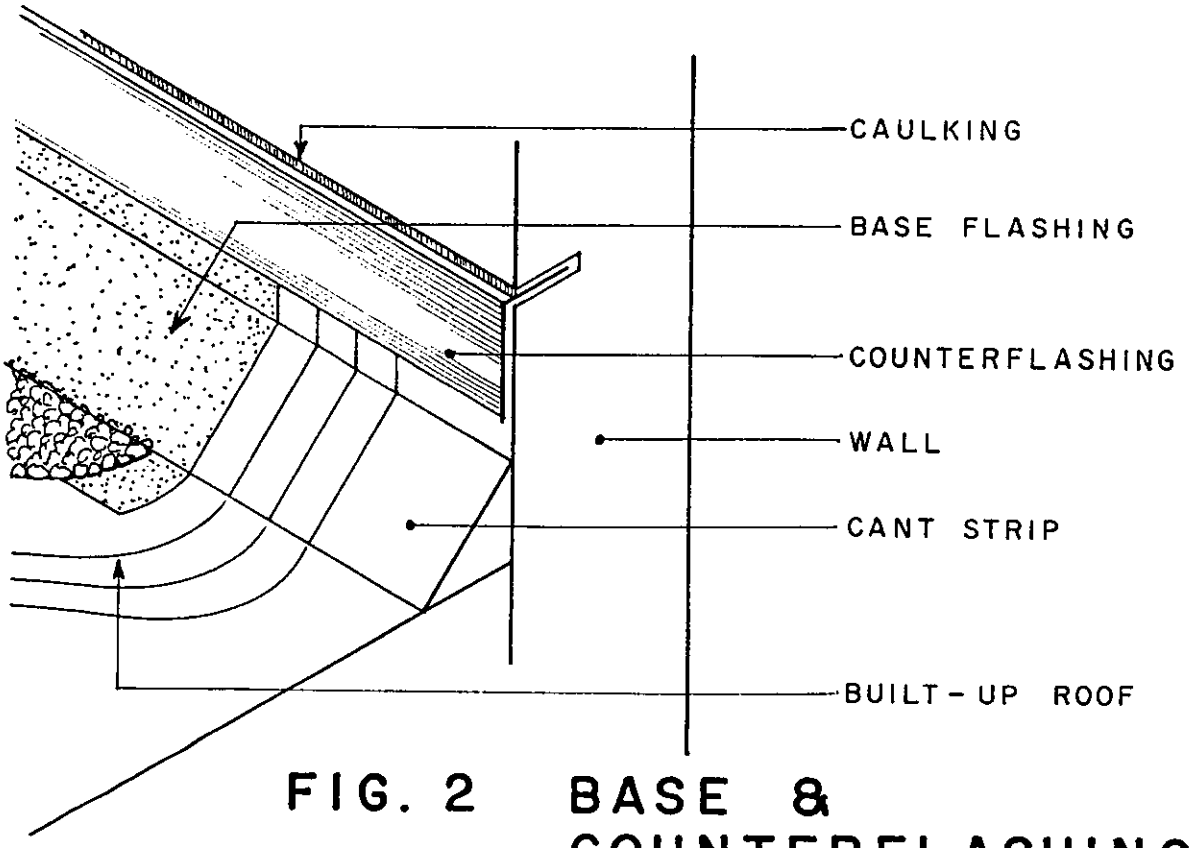
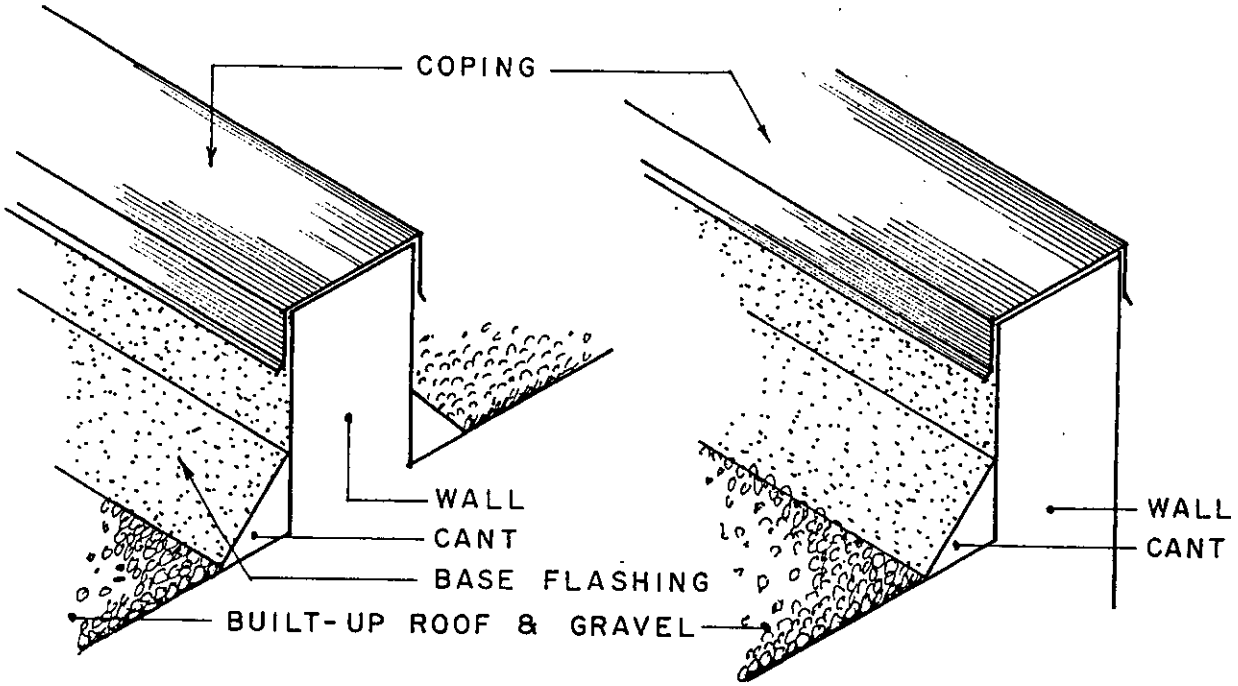


FIG. 2 BASE & COUNTERFLASHING



(A) ROOF BOTH SIDES

(B) ROOF ONE SIDE

FIG. 3 COPING

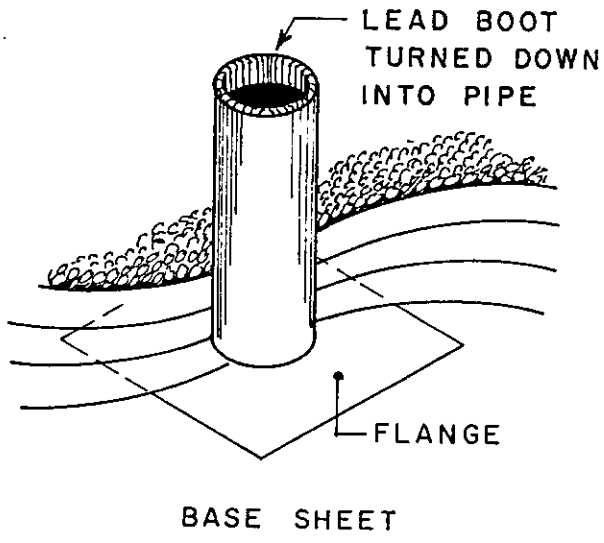


FIG. 4
VENT FLASHING

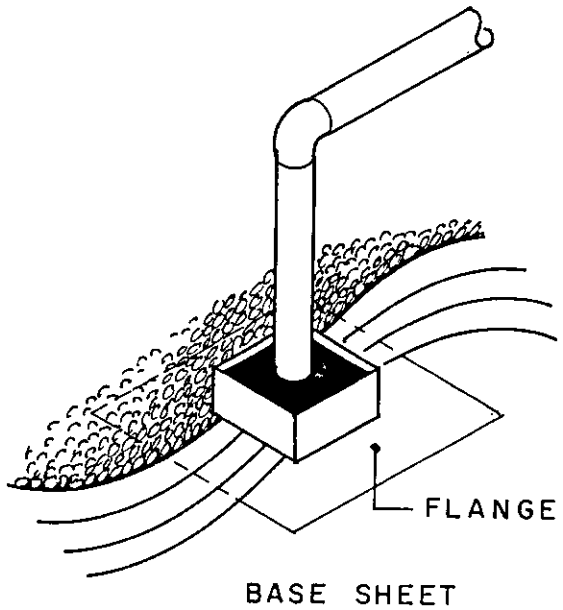


FIG. 5
PITCH PAN

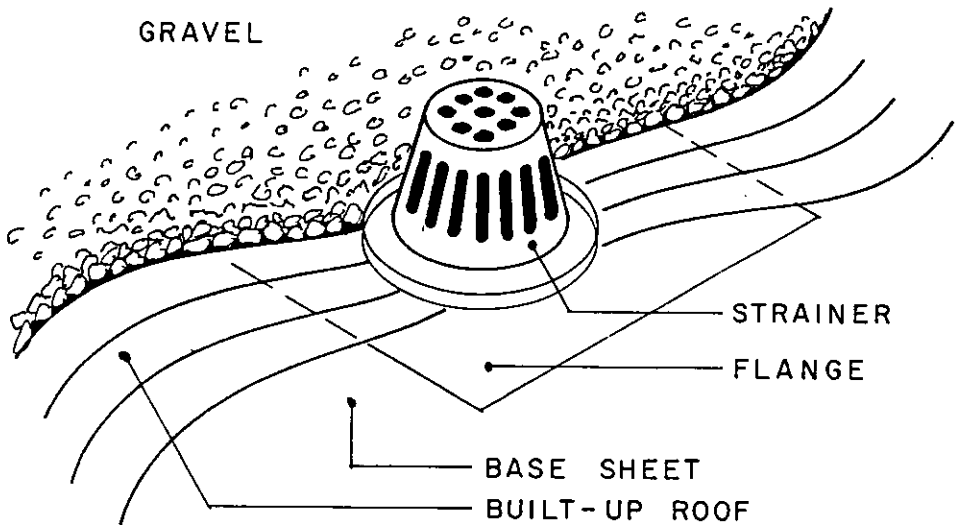


FIG. 6 ROOF DRAIN

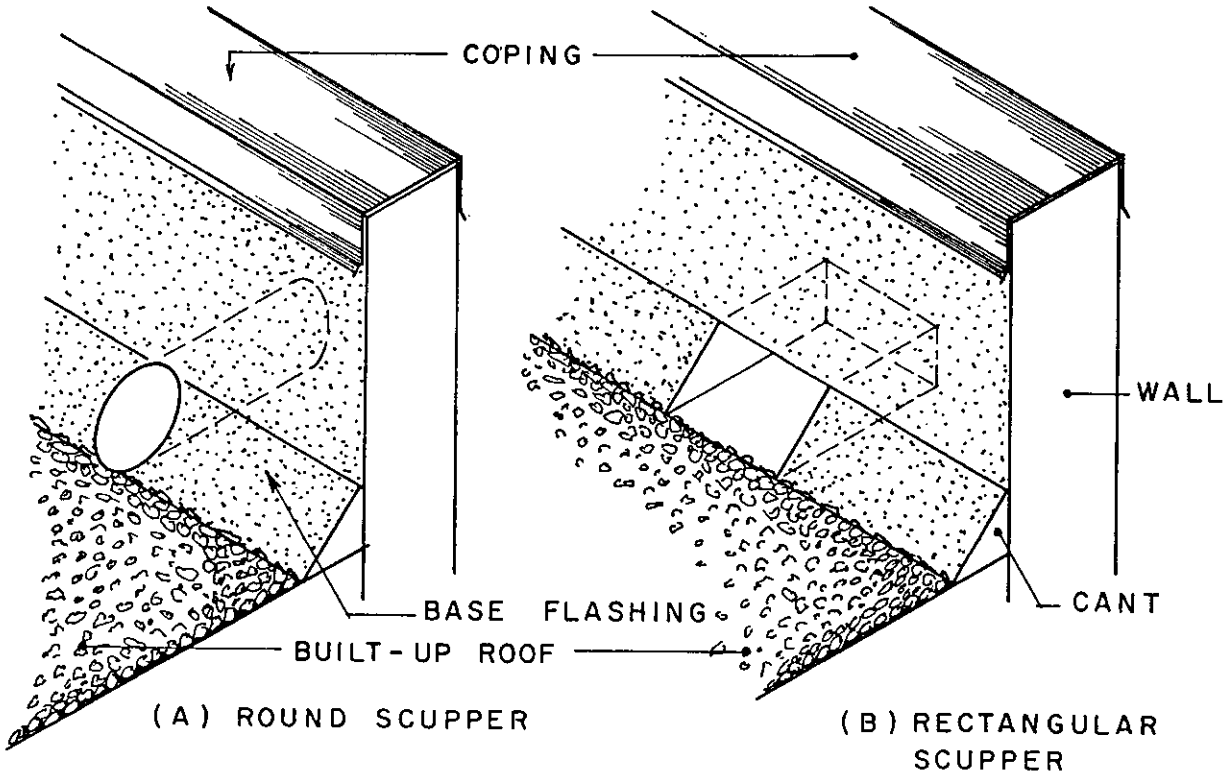


FIG. 7 SCUPPERS

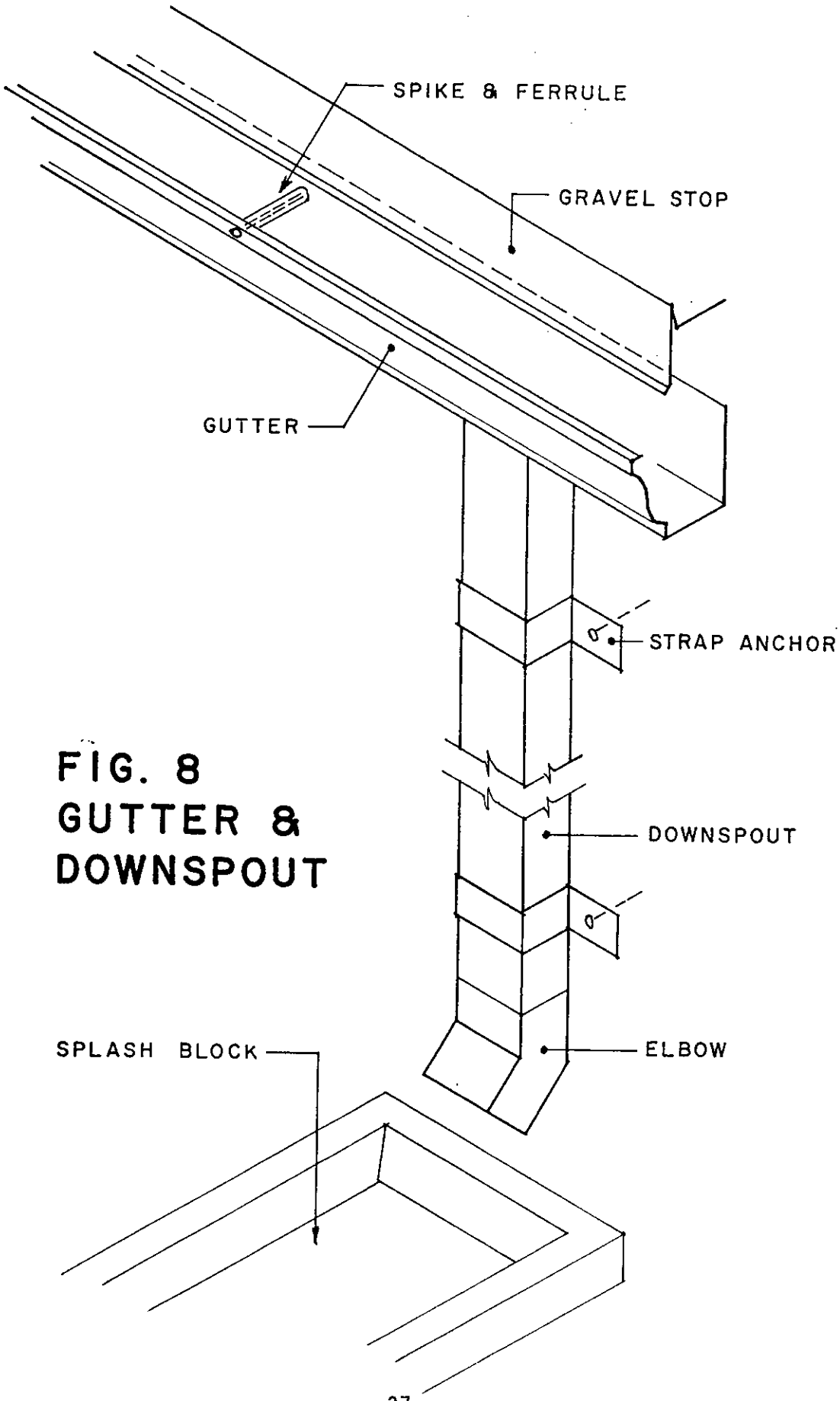


FIG. 8
GUTTER &
DOWNSPOUT

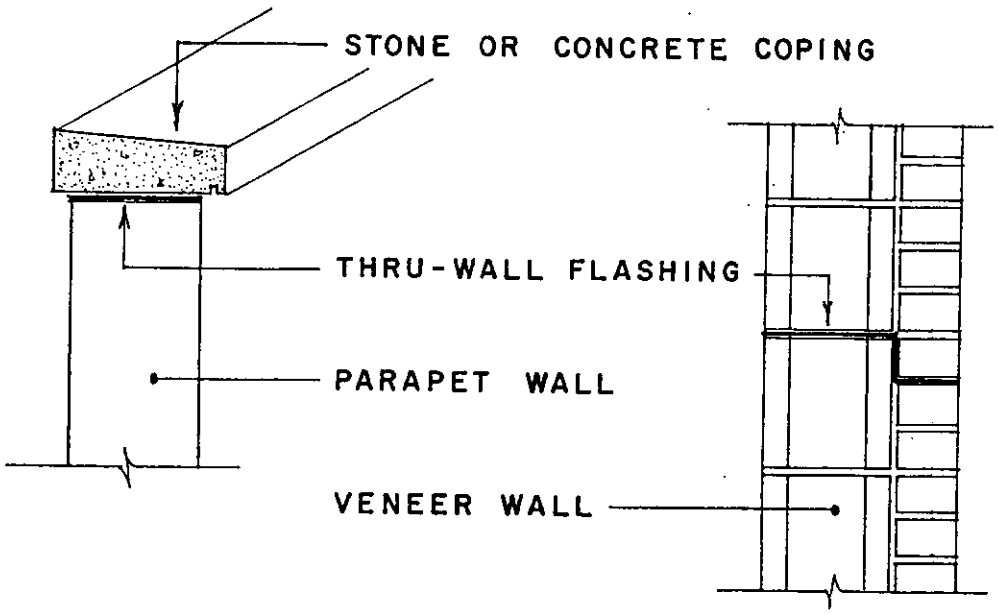


FIG. 9 THRU-WALL FLASHING

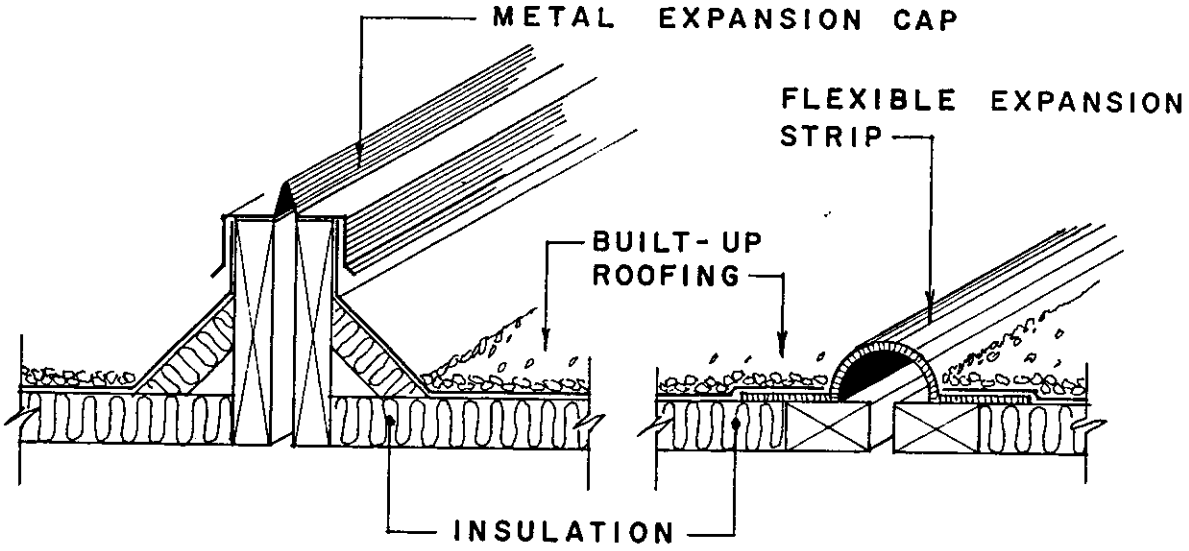


FIG. 10 EXPANSION JOINTS

SEMIANNUAL ROOF INSPECTION REPORT FORM

Building: _____ Date of Inspection: _____

Location: _____ 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:
   _____
   _____

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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 _____

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 litter. Type _____
   Found loose objects. Type _____

SEMIANNUAL ROOF INSPECTION REPORT FORM
PAGE 4

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:

   _____
   _____

BIBLIOGRAPHY

For further information on roofing maintenance, the following references are suggested.

1. "MANUAL OF ROOF MAINTENANCE AND ROOF REPAIR", 1981
   National Roofing Contractors Association (NRCA) and the Asphalt Roofing Manufacturers Association (ARMA)

2. "ROOF MAINTENANCE", 1980
   The Roofing Industry Educational Institute (RIEI)

3. "BUILT-UP ROOF MANAGEMENT PROGRAM", 1980
   Department of the Air Force