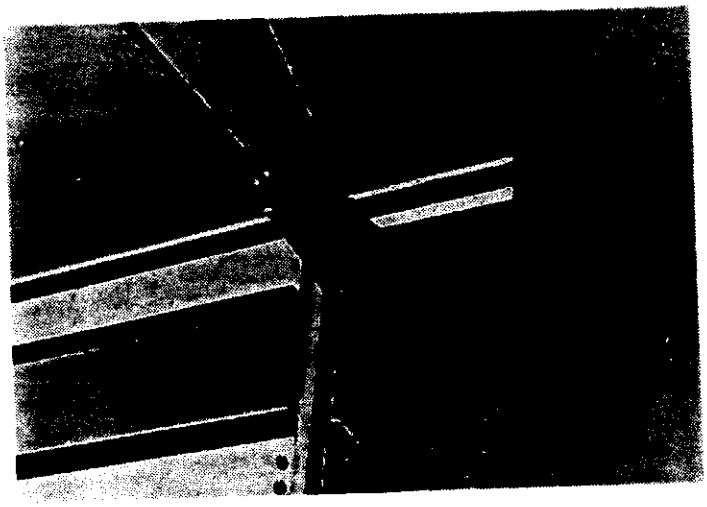
TECHNICAL PUBLICATION NO. 55

INSTRUCTOR'S MANUAL – THREE-DAY ROOFING COURSE FOR THE FLORIDA SCHOOL SYSTEM

SPONSORED BY A GRANT FROM THE BUILDING CONSTRUCTION INDUSTRY ADVISORY COMMITTEE



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1988

THIS THREE-DAY COURSE AND THE INSTRUCTOR'S MANUAL WAS PREPARED FOR THE SCHOOL SYSTEM IN FLORIDA. THE PURPOSE IS TO SAVE THE STATE OF FLORIDA MONEY BY PROVIDING INSTRUCTION IN ROOFING TO THOSE WHO WORK IN AND FOR THE SCHOOL SYSTEM. THIS WILL LEAD TO MORE EFFECTIVE ROOF MAINTENANCE, REPAIR AND CONSTRUCTION.

TECHNICAL PUBLICATION NO. 55

INSTRUCTOR'S MANUAL - THREE-DAY ROOFING COURSE FOR THE FLORIDA SCHOOL SYSTEM

THIS INSTRUCTOR'S MANUAL IS THE FINAL REPORT ON A GRANT FROM DOE, CONTRACT NO. 085-067. THE PROJECT WAS SPONSORED BY THE BUILDING CONSTRUCTION INDUSTRY ADVISORY COMMITTEE (BCIAC).

THE TITLE OF THE GRANT WAS "EVALUATION OF ALTERNATIVE SYSTEMS TO THE BUILT-UP ROOF." THE REASON THAT THIS COURSE WAS PREPARED AND DOES NOT APPEAR TO MATCH THE TITLE OF THE GRANT IS THAT THE BUILDING CONSTRUCTION INDUSTRY ADVISORY COMMITTEE FELT THAT IT WAS ESSENTIAL TO DISSEMINATE THIS INFORMATION AND CAUSE THE COURSE TO BE DEVELOPED AND THE MANUAL PREPARED UNDER THIS GRANT.

PREPARED BY: ROBERT E. CROSLAND
LUTHER J. STRANGE, JR.

SCHOOL OF BUILDING CONSTRUCTION
UNIVERSITY OF FLORIDA

JUNE 1988

O U T L I N E O F C O U R S E

FIRST DAY

8:00 - 9:50am	LESSON 1, ROOF DESIGN GENERAL DESIGN CONSIDERATIONS	RD 1
9:30 - 10:10am	BREAK	
10:10 - 12:00	LESSON 2, ROOF DESIGN DECKS AND DRAINAGE	RD 2
12:00 - 1:00pm	LUNCH	
1:00 - 2:50pm	LESSON 3, ROOF DESIGN FUNDAMENTALS OF BUILT-UP ROOFING MEMBRANES	RD 3
2:50 - 3:10pm	BREAK	
3:10 - 5:00pm	LESSON 4, ROOF DESIGN PENETRATIONS, FLASHINGS AND SHEET METAL DETAILS	RD 4

SECOND DAY

8:00 - 9:50am	LESSON 5, ROOF DESIGN QUALITY CONTROL INSPECTIONS	RD 5
9:50 - 10:10am	BREAK	
10:10 - 12:00	LESSON 6, ROOF DESIGN FIELD TRIP, ROOF INSPECTION	RD 6
12:00 - 1:00pm	LUNCH	
1:00 - 2:50pm	LESSON 1, ROOF MAINTENANCE ESTABLISHING AND CONDUCTING A ROOF MAINTENANCE PROGRAM, INCLUDING INSPECTIONS	RM 1
2:50 - 3:10pm	BREAK	
3:10 - 5:00pm	LESSON 2, ROOF MAINTENANCE	RM 2
	FIELD TRIP, MAINTENANCE INSPECTIONS	

THIRD DAY

8:00 - 9:50am	LESSON 3, ROOF MAINTENANCE RM 3 TROUBLE SHOOTING AND ROOF REPAIR
9:50 - 10:10am	BREAK
10:10 - 12:00	LESSON 4, ROOF MAINTENANCE RM 4 MAINTENANCE AND ROOF REPAIR
12:00 - 1:00pm	LUNCH
1:00 - 2:50pm	LESSON 5, ROOF MAINTENANCE RM 5 MAINTANCE REPAIR OF ROOF FLASHING AND DRAINAGE
2:50 - 3:10pm	BREAK
3:10 - 5:00pm	LESSON 6, ROOF MAINTENANCE RM 6 MAINTENANCE VS. REPLACEMENT AND REVIEW OF ROOF MAINTENANCE

LESSON PLAN 1

1. SUBJECT: ROOF DESIGN

2. OBJECTIVES: TO PROVIDE GUIDELINES FOR THE PROPER DESIGN OF ROOF SYSTEMS

3. LESSON OUTLINE:

	SUBJECT	TIME REQUIRED
	INTRODUCTION	15 MINUTES
A.	SIZE AND SHAPE OF ROOF	15 MINUTES
B.	EXPANSION JOINTS AND AREA DIVIDERS	30 MINUTES
C.	ROOF MOUNTED EQUIPMENT	20 MINUTES
D.	PENTHOUSES	15 MINUTES
E.	QUESTIONS AND ANSWERS	15 MINUTES
	TOTAL	110 MINUTES

4. TRAINING AIDS:

A. 35mm SLIDE PROJECTOR

B. OVERHEAD PROJECTOR

C. SCREEN

FIRST DAY - LESSON 1

8:00 - 9:50

ROOF DESIGN MANUAL

INTRODUCTION (15 MINUTES)

THE TERM "ROOF FAILURE", IN THE CONTEXT OF THIS MANUAL, IS USED TO DENOTE THE FAILURE OF A ROOFING TO MAINTAIN ITS WATERTIGHT INTEGRITY FOR A REASONABLE LIFE EXPECTANCY. IN SIMPLE TERMS, THE ROOF LEAKS PREMATURELY. THE TERM ROOFING FAILURE DOES NOT IMPLY A STRUCTURAL COLLAPSE.

ROOFING FAILURES CAN INVARIABLY BE TRACED TO ONE OR MORE OF THE FOLLOWING FACTORS:

a) DESIGNS: POOR PLANS, SPECIFICATIONS, DETAILS OR CHOICE OF MATERIALS.

B) MATERIALS: POOR QUALITY OR IMPROPER USE.

C) INSTALLATION: POOR WORKMANSHIP, UNSKILLED LABOR OR CARELESSNESS.

D) INSPECTION: INADEQUATE QUALITY CONTROL IN THE FIELD.

E) MAINTENANCE: NEGLIGENCE OR ABUSE OF ROOFING AFTER INSTALLATION.

OUR MAJOR CONCERN HERE IS THE FIRST MENTIONED FACTOR -- DESIGN. IF A ROOF IS IMPROPERLY DESIGNED, THE OTHER FOUR FACTORS CANNOT OVERCOME THIS DEFICIENCY. ARCHITECTS PROBABLY DESIGN MORE ROOF SYSTEMS THAN ANY OTHER PROFESSIONAL GROUP, YET THEY ARE SELDOM ADEQUATELY TRAINED IN THIS SPECIFIC AREA OF EXPERTISE. IN FACT, OF ALL LITIGATION AGAINST ARCHITECTS, MORE INVOLVE ROOFING THAN ALL OTHER BUILDING COMPONENTS COMBINED.

WHILE A KNOWLEDGE OF MATERIALS AND INSTALLATION METHODS ARE ESSENTIAL IN ROOF DESIGN, THERE ARE SEVERAL SPECIAL DESIGN PROBLEMS THAT SEEM TO PERSIST IN COMMON USAGE. SOME OF THE MORE PRONOUNCED AND RECURRING PROBLEMS IN ROOFING DESIGN WILL BE DISCUSSED.

ROOF DESIGN -- GENERAL DESIGN CONSIDERATIONS

A. SIZE & SHAPE OF ROOF (15 MINUTES)

THE LOGICAL STARTING POINT IN ROOF DESIGN WILL BE DETERMINED BY THE SIZE AND SHAPE OF THE ROOF. BOTH OF THESE ELEMENTS ARE MAJOR FACTORS IN SELECTING THE TYPE OF ROOF SYSTEM TO BE USED.

LARGER ROOF AREAS MAY REQUIRE EXPANSION JOINTS TO CONTROL THERMAL EXPANSION AND CONTRACTION, AND OFTEN NECESSITATE SPECIAL DRAINAGE CONSIDERATIONS TO DISCHARGE THE RUN-OFF. COVERING LARGE AREAS ALSO PRESENTS AN IMPORTANT COST FACTOR IN THE ROOF SYSTEM SELECTION PROCESS.

SHAPE, PARTICULARLY "SLOPE", CAN LIMIT THE CHOICES OF ROOF SYSTEMS AVAILABLE OR APPROPRIATE. TOO LITTLE SLOPE MEANS POOR DRAINAGE, AND PONDING OF WATER MAY RESULT. TOO MUCH SLOPE ELIMINATES MOST BUILT-UP ROOF SYSTEMS (BURS) AS A VIABLE ALTERNATIVE. COMPLEX ROOF SHAPES REQUIRE SPECIAL ATTENTION TO DETAILS, SUCH AS FLASHINGS, GUTTERS OR DRAINS, VALLEYS AND RIDGES. ROOF SHAPE ALSO EFFECTS WIND FLOW, AND MAY INCREASE THE UP-LIFT FORCE DUE TO NEGATIVE PRESSURES (SIMILAR TO AIRPLANE WINGS).

B. EXPANSION JOINTS & AREA DIVIDERS (30 MINUTES)

1. EXPANSION JOINTS

A SERIOUS DESIGN PROBLEM WHICH FREQUENTLY OCCURS IN ROOFING SYSTEMS IS THE ABSENCE OF PROPER EXPANSION JOINTS. BUILDINGS REQUIRE STRUCTURAL EXPANSION/CONTRACTION JOINTS EVERY 150' to 200' OF LENGTH, OR WHEN WINGS CHANGE DIRECTION, SUCH AS IN "L" OR "H" SHAPED BUILDINGS. WHENEVER THERE ARE STRUCTURAL EXPANSION/CON- TRACTION JOINTS IN THE BUILDING, THERE MUST ALSO BE EXPANSION JOINTS IN THE ROOF SYSTEM. BUT ROOF ASSEMBLIES OFTEN REQUIRE EXPANSION JOINTS EVEN WHEN THE BUILDING STRUCTURE DOES NOT, PARTICULARLY WHERE THERE IS A CHANGE IN STRUCTURAL DIRECTION!

ANY MOVEMENT IN THE ROOF DECK CAN CAUSE THE ROOFING MEMBRANE TO TEAR OR RIDGE. MOST COMMONLY THIS OCCURS WHERE THERE IS A CHANGE IN THE ROOF DECK MATERIALS, OR WHEN THE DECK MATERIAL CHANGES DIRECTIONS. FOR EXAMPLE, CORRUGATED STEEL SHEETS ARE OFTEN USED AS A ROOF DECK. THESE SHEETS ARE USUALLY TACK-WELDED AT RIGHT ANGLES TO THE STRUCTURAL FRAME. WHEN THE STRUCTURAL MEMBERS CHANGE DIRECTION, SO DO THE CORRUGATED STEEL SHEETS. WHERE THIS CHANGE OCCURS, THE EXPANSION AND CONTRACTION OF THE DECKING WILL OCCUR IN DIFFERENT DIRECTIONS—THUS TENDING TO TEAR THE ROOFING MEMBRANE. TO RELIEVE THIS, EXPANSION JOINTS SHOULD BE PROVIDED WHERE THERE IS A CHANGE IN DECK.

WHILE THERE ARE SEVERAL TYPES OF PREFORMED ELASTIC MATERIALS MANUFACTURED FOR "CONTROL" JOINTS IN BUILT-UP ROOFING, MOST EXPERTS RECOMMEND A STANDING CURB TYPE, WITH METAL CAP WHERE BUILDING EXPANSION OCCURS. CARE MUST BE EXERCISED IN USING ANY TYPE OF EXPANSION JOINT, HOWEVER, BECAUSE THEY PREVENT THE FLOW OF WATER ACROSS THEM. ROOF DRAINAGE MUST BE DESIGNED SO THAT EXPANSION JOINTS (EVEN LOW PROFILE TYPES) DO NOT IMPEDE THE WATER FLOW.

EXPANSION JOINTS ARE STRUCTURAL SEPARATIONS BETWEEN TWO BUILDING ELEMENETS, AND THEY SERVE TWO FUNCTIONS: ONE, ACCOMMODATE MOVEMENT OF THE ROOF ASSEMBLY RESULTING FROM THERMAL EXPANSION AND CONTRACTION; AND TWO, RELIEVE STRESS BUILD-UP IN THE ROOF MEMBRANE, THUS PREVENTING SPLITTING AND RIDGING.

ROOF EXPANSION JOINTS SHOULD BE PROVIDED AT THE FOLLOWING LOCATIONS:

A. WHERE EXPANSION/CONTRACTION JOINTS OCCUR IN THE STRUCTURAL SYSTEM.

B. WHERE STRUCTURAL STEEL FRAMING OR DECKING CHANGE DIRECTIONS.

C. WHERE THERE IS A CHANGE IN DECKING MATERIAL.

D. WHERE SEPARATE BUILDING WINGS OCCUR, SUCH AS IN "T", "H", "U", "L" SHAPED BUILDINGS.

E. WHERE ADDITIONS ARE CONNECTED TO EXISTING STRUCTURES.

F. WHERE INTERIOR HEATING/COOLING TEMPRATURES VARY, SUCH AS OFFICES ADJACENT TO WAREHOUSE SPACE.

CURB-TYPE EXPANSION JOINTS ARE RECOMMENDED, AND THEY SHOULD EXTEND AT LEAST 8" ABOVE THE ROOF SURFACE. (SEE DETAIL A)

2. AREA DIVIDERS

AREA DIVIDERS, ALSO CALLED "RELIEF JOINTS", ARE SIMILAR TO EXPANSION JOINTS EXCEPT THAT THEY DO NOT PROVIDE FOR MOVEMENT IN THE ROOF ASSEMBLY. AREA DIVIDERS SERVE TWO FUNCTIONS: ONE, THEY DIVIDE LARGE ROOFS INTO SMALLER AREAS OF APPROXIMATELY EQUAL SIZE; AND TWO, THEY ANCHOR THE MEMBRANE AND RELIEVE STRESS BUILD-UP IN THE MEMBRANE. THEY SHOULD BE LOCATED AT HIGH POINTS IN THE ROOF, WITH DRAINAGE AWAY FROM THE DIVIDERS IN BOTH DIRECTIONS.

CURB TYPE AREA DIVIDERS ARE RECOMMENDED, AND THEY SHOULD EXTEND A MINIMUM OF 8" ABOVE THE ROOF SURFACE. (SEE DETAIL B)

C. <u>ROOF-MOUNTED EQUIPMENT</u> (20 MINUTES)

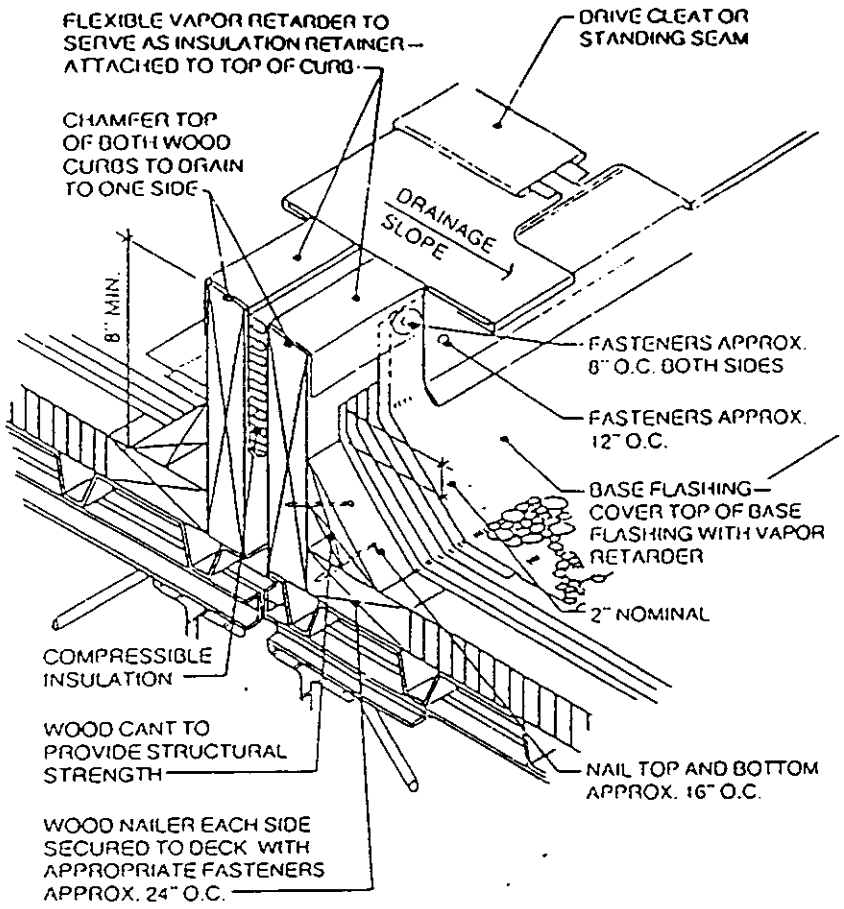
THIS RANKS AS THE MOST COMMON MAJOR ROOF DESIGN PROBLEM. THE PLACEMENT OF AIR CONDITIONING EQUIPMENT, ELECTRICAL EQUIPMENT, VENTILATING FANS, ANTENNAE, SIGNS AND MANY OTHER BUILDING COMPONENTS ON ROOF SURFACES COMPOUNDS SEVERAL ROOF PROBLEMS. FIRST, THE ORIGINAL INSTALLATION OF THE ROOFING IS MORE COMPLICATED, AND REPAIR WORK MORE DIFFICULT. SECOND, THE WEIGHT/DEFLECTION, WIND SWAY AND VIBRATIONS OFTEN CAUSE MOVEMENT IN THE STRUCTURAL FRAMES THAT CAN BE DETRIMENTAL TO ROOF MEMBRANES. THIRD, THE BASES (OR POINTS OF ATTACHMENT) OF THIS EQUIPMENT ARE POTENTIAL SOURCES OF LEAKS, AND OFTEN DISRUPT THE NORMAL DRAINAGE FLOW. FOURTH, THE EQUIPMENT

ITSELF, WHEN EXPOSED TO THE WEATHER, DETERIORATES MORE RAPIDLY. LAST, BUT NOT LEAST, THE LOAD TO ADEQUATE STRUCTURAL SUPPORTS. SUCH BASE CURBS SHOULD BE LOCATED AT HIGH POINTS IN THE ROOF, WITH DRAINAGE AWAY FROM THE CURB. (SEE DETAIL F).

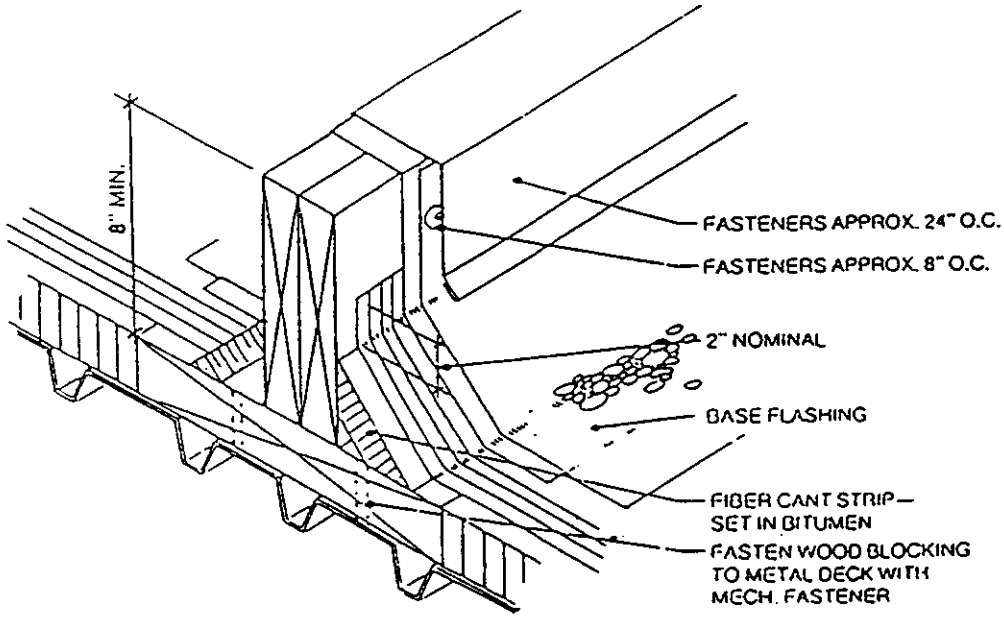
D. PENTHOUSES (15 MINUTES)

WHERE POSSIBLE, PENTHOUSES SHOULD BE USED TO ENCLOSE ROOF-MOUNTED EQUIPMENT. PENTHOUSES LOOK BETTER, PROTECT THE EQUIPMENT FROM THE WEATHER, PROVIDE BETTER MAINTENANCE FACILITY, OFFER MORE SECURITY FOR THE EQUIPMENT, AND PRESENT LESS CHANCE OF ROOFING PROBLEMS. PENTHOUSES ARE ECONOMICAL, ESPECIALLY WHEN ROOF AND EQUIPMENT LIFE-CYCLE COSTS ARE CONSIDERED. THEY CAN PROVIDE SHADE, SHELTER AND VENTILATION, WHILE AT THE SAME TIME BE REMOVABLE FOR REPLACEMENT OF HEAVY EQUIPMENT.

QUESTIONS AND ANSWERS: (15 MINUTES)

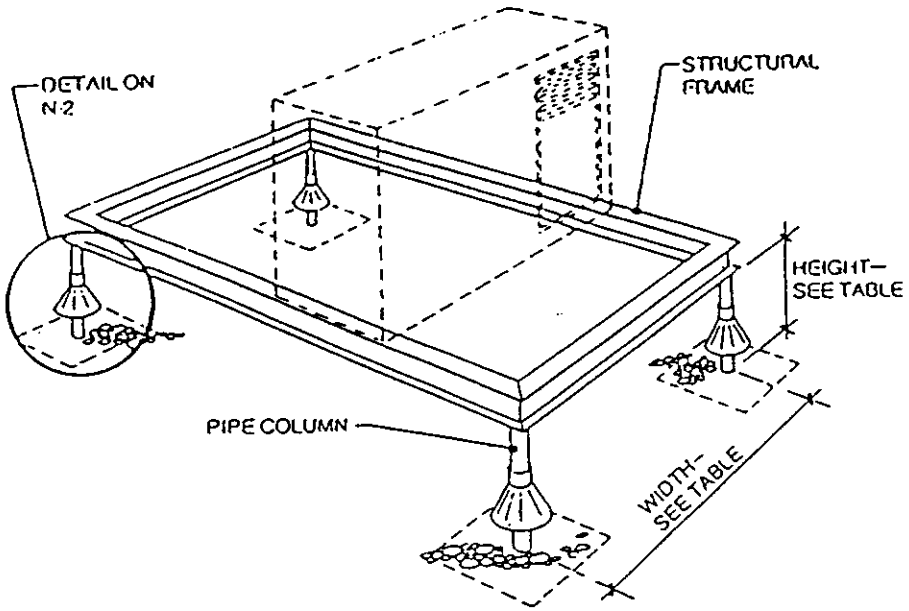


DETAIL A*



DETAIL B*

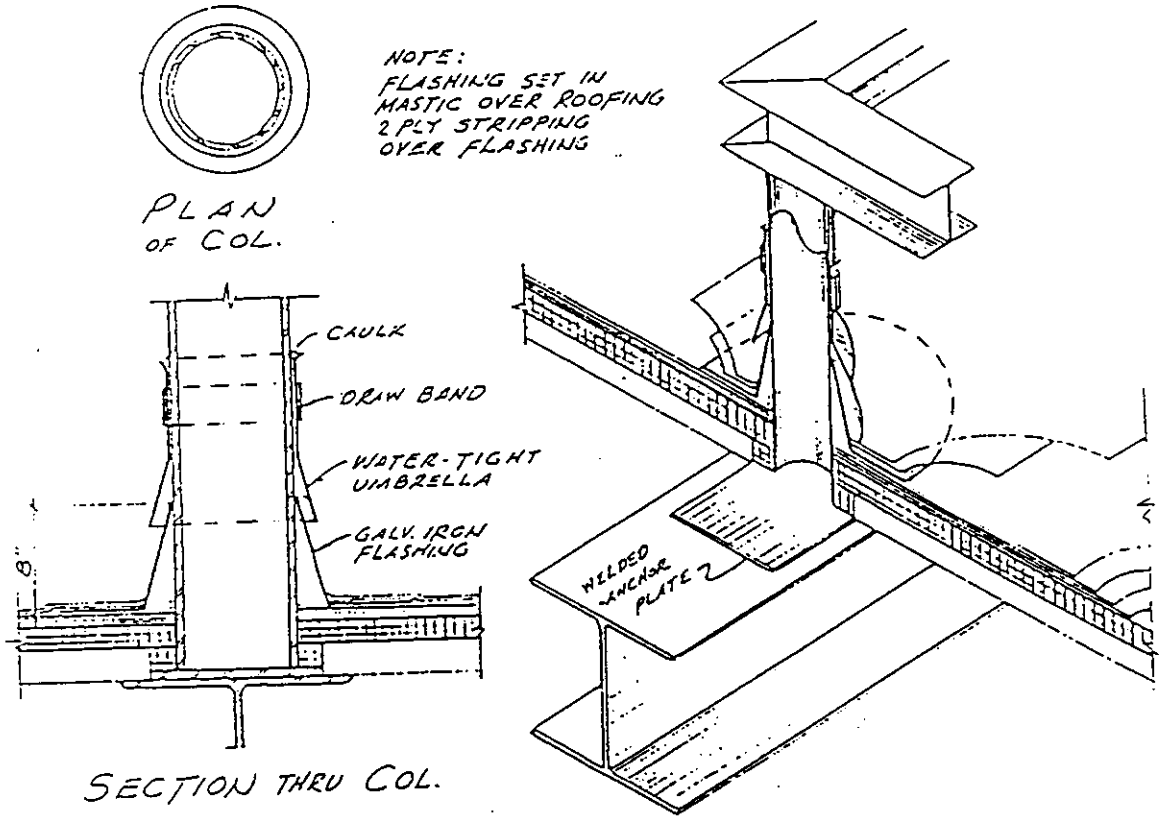
*National Roofing Contractors Association "Manual of Roofing and Waterproofing."



WIDTH OF EQUIPMENT	HEIGHT OF LEGS
UP TO 24"	14"
25" TO 36"	18"
37" TO 48"	24"
49" TO 60"	30"
61" AND WIDER	48"

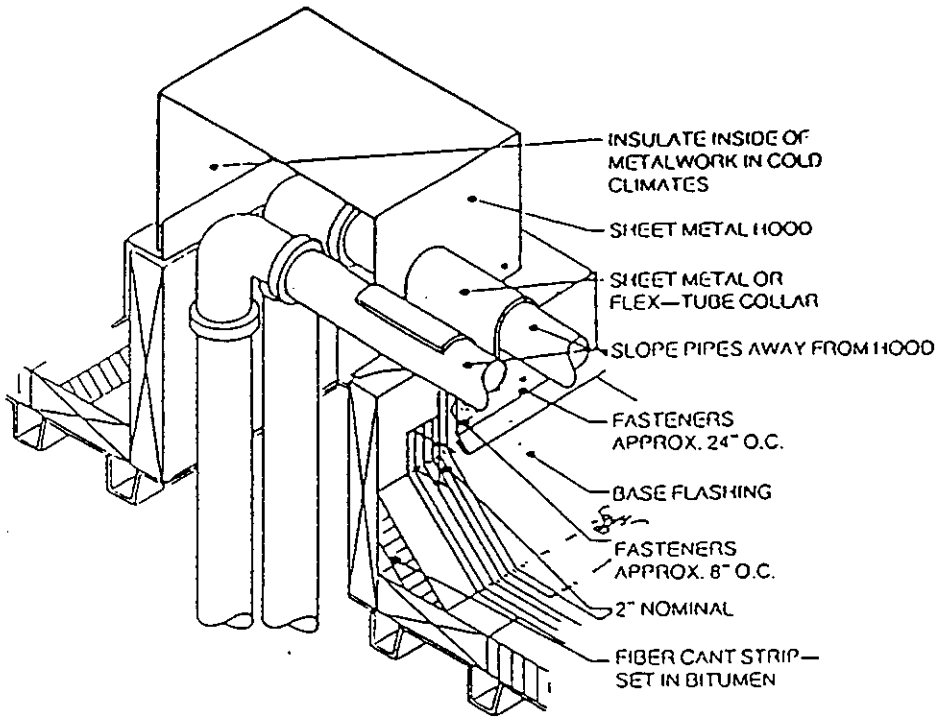
DETAIL C*

*National Roofing Contractors Association "Manual of Roofing and Waterproofing."

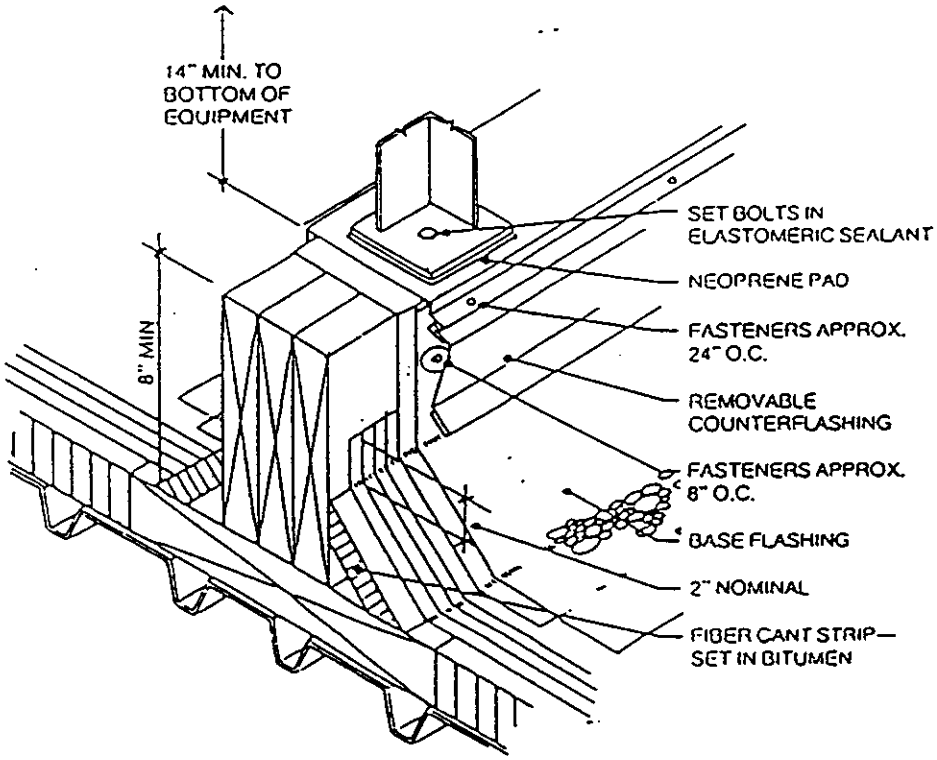


DETAIL D*

*Chicago Roofers' Joint Apprenticeship Committee "Roofers' Apprentice Training Manual"

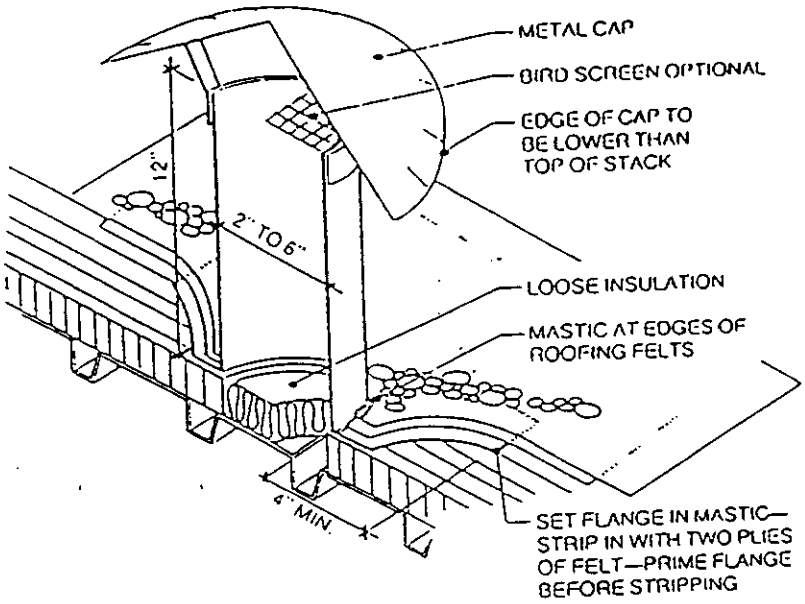


DETAIL E*



DETAIL F*

*National Roofing Contractors Association "Manual of Roofing and Waterproofing."



NOTE:

THIS DETAIL IS USED TO RELIEVE MOISTURE VAPOR PRESSURE FROM INSULATION. THE MOISTURE MAY HAVE ENTERED DUE TO LEAKS. FAULTY VAPOR RETARDERS OR DURING CONSTRUCTION. THE SPACING OF RELIEF VENTS IS DETERMINED BY THE TYPE OF INSULATION USED AND THE AMOUNT OF MOISTURE TO BE RELIEVED. THIS DETAIL IS SOMETIMES USED FOR NEW ROOFS WHEN VAPOR RETARDERS ARE USED AND A VENTING SYSTEM IS DESIRED.

DETAIL G*

*National Roofing Contractors Association "Manual of Roofing and Waterproofing."

LESSON PLAN 2

1. SUBJECT: ROOF DESIGN

2. OBJECTIVES: TO PROVIDE GUIDELINES FOR THE SELECTION OF ROOF DECKS, AND DRAINAGE

3. LESSON OUTLINE:

SUBJECT	TIME REQUIRED
MATERIALS	10 MINUTES
WOOD PLANK OR PLYWOOD DECKING	5 MINUTES
CEMENT-WOOD FIBER PANELS	5 MINUTES
STEEL ROOF DECKS	5 MINUTES
REINFORCED CONCRETE ROOF DECKS	5 MINUTES
PRECAST AND PRESTRESSED CONCRETE SLABS	5 MINUTES
POURED GYPSUM ROOF DECKS	5 MINUTES
THERMO-SETTING INSULATING FILL	5 MINUTES
MOISTURE CONTROL	5 MINUTES
VENTILATION	5 MINUTES
VAPOR RETARDERS	15 MINUTES
SELF DRYING ROOF CONCEPT	5 MINUTES
SLOPE	5 MINUTES
DRAINAGE	15 MINUTES
QUESTIONS AND ANSWERS	15 MINUTES
TOTAL	110 MINUTES

4. TRAINING AIDS:

A. 35mm SLIDE PROJECTOR

B. OVERHEAD PROJECTOR

C. SCREEN

FIRST DAY - LESSON 2

10:10 - 12:00

DECKS & DRAINAGE

A. MATERIALS (10 MINUTES)

A WIDE VARIETY OF MATERIALS ARE AVAILABLE FOR USE AS ROOF DECKING. IN SELECTING THE MOST APPROPRIATE DECKING, THE DESIGNER SHOULD CONSIDER THE ENTIRE ROOF SYSTEM AS AN ASSEMBLY OF INTERACTING COMPONENTS, OR ELEMENTS, EACH DESIGNED TO BE COMPLEMENTARY TO THE WHOLE. EACH COMPONENT MUST BE COMPATIBLE WITH THE OTHER ELEMENTS, AND CONTRIBUTE TO THE FUNCTION OF THE ROOF SYSTEM AS A PART OF THE BUILDING ENVELOPE. THE SELECTION PROCESS SHOULD CONSIDER AT LEAST THE FOLLOWING FACTORS:

A. STRUCTURAL FRAMING (TYPE AND MATERIAL).

B. FIRST COST (INSTALLATION) AND LIFE-CYCLE COST (LONG TERM).

C. CLIMATE TO WHICH IT IS SUBJECTED.

D. CODE REQUIREMENTS (WIND AND FIRE RESISTANCE).

E. VALUE AND VULNERABILITY OF BUILDING CONTENTS.

F. LIFE EXPECTANCY AND MAINTENANCE REQUIRED.

G. INTERIOR HEATING/COOLING TEMPERATURES.

H. AVAILABILITY OF MATERIALS AND APPLICATORS.

SOME OF THE MORE GENERIC ROOF DECK MATERIALS ARE DISCUSSED, WITH RECOMMENDATIONS AND PRECAUTIONS.

1. WOOD PLANK OR PLYWOOD DECKING (5 MINUTES)

THESE ARE CLASSIFIED AS "NAILABLE" DECKING, AND MUST BE OF SUFFICIENT THICKNESS AND STIFFNESS TO SPAN BETWEEN SUPPORTS. PLANKING SHOULD BE SOUND,

WELL-SEASONED LUMBER (PREFERRABLY TONGUE-AND-GROOVE), AND PLYWOOD SHOULD HAVE LABELS SIGNIFYING APPROPRIATE SPAN AND EXPOSURE RATING.

ALL WOOD DECKING SHOULD BE PROTECTED FROM WEATHER AT THE CONSTRUCTION SITE, AND COVERED WITH ROOFING AS SOON AS POSSIBLE. BASE PLY OF THE MEMBRANE SHOULD BE INSTALLED OVER A DRY SEPARATOR SHEET (ROSIN-SIZED PAPER), AND MECHANICALLY FASTENED TO THE DECK. WHERE INSULATION IS TO BE USED, IT SHOULD BE MECHANICALLY FASTENED DIRECTLY TO THE DECK.

PRECAUTION: IT IS NOT UNCOMMON TO ENCOUNTER NAIL-WITHDRAWAL IN WOOD DECKING DUE TO SWELLING AND SHRINKING OF THE WOOD WITH MOISTURE CHANGES. WHERE NAILS POP UP, THEY WILL LIKELY TEAR THROUGH THE MEMBRANE. IT IS RECOMMENDED THAT RIGID INSULATION BE INSTALLED IN TWO LAYERS. THE FIRST LAYER TO BE MECHANICALLY FASTED; THE SECOND LAYER MOPPED WITH STEEP ASPHALT USING STAGGERED JOINTS. IF A VAPOR RETARDER IS USED, THE INSULATION SHOULD BE MOPPED WITH A STEEP ASPHALT OVER THE MECHANICALLY FASTENED VAPOR RETARDER.

2. CEMENT-WOOD FIBER PANELS (5 MINUTES)

THESE ARE TREATED WOOD FIBERS BONDED TOGETHER WITH PORTLAND CEMENT, AND COMPRESSED INTO RIGID PANELS. THE PANELS PROVIDE ACOUSTICAL AND THERMAL INSULATION, AND ARE NAILABLE STRUCTURAL UNITS. THEY ARE AVAILABLE AS TONGUE-AND-GROOVE PANELS FOR MECHANICAL ANCHORAGE TO STEEL JOISTS, OR WITH RABBETED EDGES FOR INSTALLATION WITH STEEL SUB-PRULINS.

CEMENT-WOOD FIBER PANELS SHOULD BE PROTECTED FROM WEATHER AT THE CONSTRUCTION SITE, AND INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S DIRECTIONS. A BAS SHEET SHOULD BE MECHANICALLY FASTENED OVER THE PANELS, AND ADDITIONAL PLYS MOPPED ON.

WHERE ADDITIONAL RIGID INSULATION IS NEEDED, IT SHOULD BE SOLID MOPPED DIRECTLY OVER THE MECHANICALLY FASTENED BASE SHEET. THE MEMBRANE IS THEN MOPPED OVER THE INSULATION.

3. STEEL ROOF DECKS (5 MINUTES)

STEEL ROOF DECKS ARE RIBBED PANELS FORMED OF COLD-ROLLED STEEL SHEETS, OF VARIOUS DEPTHS AND GAUGES TO GIVE STRENGTH AND RIGIDITY. THE PANELS MAY BE PAINTED OR GALVANIZED, AND ARE USUALLY TACK-WELDED (THROUGH WELDING WASHERS) OVER OPEN WEB STEEL JOISTS OR LIGHTWEIGHT STEEL BEAMS. DECK MANUFACTURERS PROVIDE SPAN TABLES SIMILAR TO THE ONE BELOW.*

MAXIMUM SPANS FOR 1½ INCH DEEP STEEL DECK UNITS WITH RIBS SPACED 6 INCHES APART

Gauge	Uncoated Steel Minimum Thickness in Inches	Narrow Rib	Intermediate Rib	Wide Rib
22	0.0280	4 ft. 6 in.	5 ft. 0 in.	5 ft. 6 in.
20	0.0340	5 ft. 0 in.	5 ft. 6 in.	6 ft. 0 in.
18	0.0450	6 ft. 0 in.	6 ft. 0 in.	7 ft. 0 in.
16	0.0570	6 ft. 6 in.		8 ft. 0 in.

NOTE: The above spans apply where the deck is continuous over three or more supports. Single-span conditions should be no greater than 85% of the above spans. Spans are based on the uncoated steel thickness.

"NATIONAL ROOFING CONTRACTORS ASSOCIATION "MANUAL OF ROOFING AND WATERPROOFING."

RIGID INSULATION MUST BE INSTALLED OVER STEEL DECKING TO PROVIDE THE SURFACE FOR ROOFING MEMBRANE. THE INSULATION SHOULD BE APPLIED IN TWO LAYERS. THE FIRST LAYER SHOULD BE MECHANICALLY FASTENED TO THE STEEL DECK, AND THE SECOND LAYER HOT MOPPED OVER THE FIRST WITH JOINTS STAGGERED.

4. REINFORCED CONCRETE ROOF DECKS (5 MINUTES)

STRUCTURAL REINFORCED CONCRETE ROOF SLABS SHOULD PROVIDE A SMOOTH, EVEN AND DRY SURFACE. MOISTURE IS CRITICAL. A SIMPLE TEST TO DETERMINE IF THE ROOF DECK IS DRY ENOUGH IS TO PLACE A PANE OF WINDOW GLASS OVER THE CONCRETE, AND SEAL THE EDGES WITH TAPE. ALLOW THE GLASS PANE TO REMAIN FOR AT LEAST TWO HOURS IN THE MID-DAY SUN. IF DROPLETS OF MOISTURE FORM ON THE UNDERSIDE OF THE GLASS, THE ROOF DECK IS NOT DRY ENOUGH.

WHEN THE CONCRETE DECK PASSES THE "DRYNESS TEST", THE SURFACE MUST BE PRIMED WITH ASPHALT PRIMER IF ASPHALT BITUMEN IS TO BE USED. THE MEMBRANE CAN THEN BE HOT MOPPED TO THE PRIMED DECK. WHERE COAL TAR BITUMEN IS USED, NO PRIMER IS REQUIRED.

IF A DRY SURFACE CANNOT BE OBTAINED WITHIN A REASONABLE TIME, AN ALTERNATIVE IS TO MOP A VAPOR RETARDER OVER THE DECK, AND INSTALL A LAYER OF RIGID INSULATION OVER THE VAPOR RETARDER. THE MEMBRANE CAN THEN BE APPLIED OVER THE INSULATION.

PRECAUTION: CONCRETE ROOF DECKS SHOULD BE PROVIDED WITH ADEQUATE TOP AND SIDE VENTING TO ALLOW FOR CONTINUED MOISTURE REMOVAL.

5. PRECAST AND PRESTRESSED CONCRETE SLABS (5 MINUTES)

CONCRETE SLABS MAY BE PRECAST OFF-SITE, AND A VARIETY OF SHAPES ARE AVAILABLE. THESE SLABS ARE OFTEN PRESTRESSED TO RELIEVE FLEXURAL TENSILE STRESS. PRESTRESSING USUALLY RESULTS IN CAMBER (UPWARD DEFLECTION) AT THE CENTER OF THE SPAN, AND REQUIRES CAREFUL ALIGHMENT WITH WELD-PLATES DURING INSTALLATION.

PRECAST AND PRESTRESSED SLABS ARE OFTEN PRESENT UNEVEN SURFACES, ESPECIALLY AT JOINTS. IT IS RECOMMENDED THAT A LIGHTWEIGHT CONCRETE TOPPING OR RIGID INSULATION BE INSTALLED TO PROVIDE A SMOOTH, EVEN DECK SURFACE. UNEVEN JOINTS MUST BE LEVELED BY GRINDING, OR BY USING A CEMENTITIOUS GROUT. THE GROUT SHOULD BE TAPERED TO A SLOPE OF 1/8" PER FOOT, AND SHOULD FILL ALL JOINTS AND CRACKS.

WHERE RIGID INSULATION IS TO BE USED, THE PRECAST/PRESTRESSED CONCRETE SLABS SHOULD BE PRIMED WITH ASPHALT CUTBACK. THE INSULATION IS THEN ATTACHED WITH STEEP ASPHALT.

WHEN LIGHTWEIGHT CONCRETE TOPPING IS USED OVER PRECAST OR PRESTRESSED CONCRETE SLABS IT SHOULD BE AT LEAST 2" THICK. BOTH TOP (STACK) AND EDGE VENTING IS RECOMMENDED. STACK VENTS SHOULD BE AT LEAST 2" IN DIAMETER, AND SHOULD BE SPACED TO PROVIDE 1 VENT PER 10 SQUARES OR LESS. ALLOW LIGHT-WEIGHT CONCRETE TOPPING TO DRY FOR AT LEAST 4 DAYS PRIOR TO APPLICATION OF MEMBRANE. FIRST PLY OF BUILT-UP ROOFING SHOULD BE EITHER A COATED BASE OR VENTED BASE PLY, AND IT MUST BE MECHANICALLY ATTACHED. STRIP OR SPOT MOP-PING IS NOT RECOMMENDED.

6. POURED GYPSUM ROOF DECKS (5 MINUTES)

A GYPSUM CEMENT MIXED WITH WOOD FIBERS OR MINERAL AGGREGATE AND WATER IS PLACED OVER PERMANENT FORMBOARDS WHICH PROVIDE A FINISHED UNDERSIDE TO THE ROOF DECK. A VARIETY OF FORM BOARDS ARE AVAILABLE TO PROVIDE FIRE RE-SISTANCE, THERMAL INSULATION AND ACOUSTICAL PROPERTIES. THE FORMBOARDS ARE USUALLY SUPPORTED BY BULB-TEE OR STEEL ANGLE SUB-PRULINS WELDED TO A STRUCTURAL STEEL FRAME. THE GYPSUM CONCRETE IS REINFORCED WITH WIRE MESH, AND SHOULD NOT BE LESS THAN 2" THICK (NOT INCLUDING THE FORMBOARD).

GYPSUM CONCRETE ROOF DECKS SHOULD PROVIDE A SMOOTH URFACE, FREE OF RIDGES OR DEPRESSIONS. INTERIOR VENTILATION MUST BE PROVIDED BELOW THE SLAB

TO REMOVE EXCESS MOISTURE. VENTING OF THE ROOF MEMBRANE IS ALSO RECOMMENDED, SINCE MOISTURE MAY REMAIN IN THE DECK. IF RIGID INSULATION IS TO BE PLACED OVER A GYPSUM DECK, IT SHOULD BE MOPPED OVER A VENTED VAPOR BARRIER WHICH HAS BEEN NAILED TO THE GYPSUM DECK.

ROOF MEMBRANES MAY BE APPLIED OVER A GYPSUM CONCRETE DECK AS SOON AS THE SURFACE IS FIRM ENOUGH TO SUPPORT ROOF TRAFFIC, PROVIDED THERE IS NO SURFACE WATER. THE FIRST PLY MUST BE MECHANICALLY FASTENED TO THE DECK. SPOT OR SOLID MOPPING OF THE FIRST PLY IS NOT RECOMMENDED.

7. THERMO-SETTING INSULATING FILL (5 MINUTES)

THIS IS A NON-STRUCTURAL MATERIAL USED FOR INSULATION, LEVELING OR SLOPING FOR DRAINAGE. IT CONSISTS OF PERLITE AGGREGATE MIXED WITH A HOT ASPHALT BINDER, AND IT CAN BE APPLIED OVER AN EXISTING MEMBRANE. THE HOT MIXTURE IS PLACED OVER A PRIMED SURFACE, SCREEDED, AND COMPACTED WITH A ROLLER OR HAND TAMPER TO THE SPECIFIED THICKNESS AND DENSITY. WOOD OR FIBER CANT STRIPS ARE RECOMMENDED.

THE ROOFING MEMBRANE SHOULD BE APPLIED WITH SOLID MOPPPINGS OF STEEP ASPHALT AS SOON AS POSSIBLE AFTER THE THERMO-SETTING FILL IS PLACED.

B. MOISTURE CONTROL (5 MINUTES)

MOIST AIR FLOWING UPWARD FROM THE BUILDING INTERIOR INTO THE ROOF ASSEMBLY CAN CREATE MANY PROBLEMS. CONDENSATION OF THIS MOISTURE CAN DESTROY INSULATION, RUIN SUSPENDED CEILINGS, AND BLISTER OR DETERIORATE A BUILT-UP MEMBRANE. IRONICALLY, THE MORE EFFICIENT THE INSULATION, THE MORE LIKELY CONDENSATION MAY OCCUR.

IN NORTHERN CLIMATES, WITH COLD, DRY EXTERIOR AIR AND WARM, MOIST INTERIORS, THE DIRECTION OF MOISTURE FLOW IS UPWARD. THIS UPWARD MIGRATION CAUSES THE MOIST AIR TO CONDENSE WHEN REACHING A COOLER SURFACE. IN SOUTHERN CLIMATES, WITH WARM, HUMID OUTSIDE AIR AND COOLER AIR-CONDITIONED

INTERIORS, THE DIRECTION OF MOISTURE FLOW IS REVERSED. THE PROBLEM IS THAT WITH SEASONAL CHANGES IN CLIMATE, THE MOISTURE FLOW MAY VARY OR BECOME UNSTABLE.

THERE ARE THREE BASIC TECHNIQUES FOR LIMITING MOISTURE WITHIN A ROOF ASSEMBLY: (1) VENTILATE THE AIR SPACE BELOW THE ROOF; (2) USE A VAPOR RETARDER TO PREVENT THE FLOW OF MOISTURE INTO THE ROOF SYSTEM; (3) USE THE "SELF-DRYING ROOF CONCEPT." THESE THREE APPROACHES ARE DISCUSSED INDIVIDUALLY.

1. VENTILATION (5 MINUTES)

GENERAL VENTILATION OF THE AIR SPACE BELOW THE ROOF IS RECOMMENDED AS THE MOST RELIABLE. FOR SLOPED ROOFS A NATURAL CONVECTIVE CIRCULATION CAN BE CREATED BY PLACING AIR INLETS LOW, AND OUTLETS HIGHER UP (PREFERRABLY AT THE RIDGE). THIS NATURAL AIR FLOW PRODUCES EVAPORATION OF MOISTURE, THUS REDUCING ANY TENDANCY FOR CONDENSATION.

IN FLAT ROOFS, HOWEVER, THE PROBLEM OF VENTILATION IS MORE DIFFICULT, ESPECIALLY FOR LARGE ROOF AREAS. POWERED VENTILATOR FANS WORK, BUT INCREASE BOTH INITIAL AND OPERATING COSTS. WIND-DRIVEN TURBIN FANS ARE A MORE ECONOMICAL SOLUTION. EITHER WAY, SIDE OR BOTTOM VENTS ARE REQUIRED FOR INLET AIR. THIS MEANS THAT AIR TEMPERATURES IN THE LOFT SPACE (BETWEEN ROOF AND CEILING) WILL BE CLOSE TO THE OUTDOOR TEMPERATURE. ANY LEAKAGE OF WARM, MOIST AIR INTO THIS LOFT SPACE COULD RESULT IN CONDENSATION ON COLD SURFACES. THUS, AN EFFECTIVE AIR SEAL IS REQUIRED FOR THE CEILING, AND ALL DUCTS AND PIPES IN THE LOFT MUST BE INSULATED.

@. VAPOR RETARDERS (15 MINUTES)

VAPOR RETARDERS, SOMETIMES CALLED VAPOR "BARRIERS", ARE USED TO LIMIT THE FLOW OF MOISTURE VAPOR WITHIN A ROOF SYSTEM. KNOWING WHEN AND WHERE TO

USE VAPOR RETARDERS REQUIRES SOME UNDERSTANDING OF THE SCIENCE OF PSYCHROMETRICS (THE STUDY OF AIR AND ITS PROPERTIES).

MOISTURE VAPOR IS REALLY WATER WHICH HAS EVAPORTED INTO INVISIBLE PARTICLES SUSPENDED IN THE AIR. THE RATE OF EVAPORATION, OR VAPORIZATION, IS DIRECTLY PROPORTIONAL TO TEMPERATURE. THE HIGHER THE TEMPERATURE, THE MORE QUICKLY VAPORIZATION OCCURS. WARM AIR CAN HOLD MORE MOISTURE VAPOR THAN COLD AIR, BUT ALL AIR CONTAINS SOME MOISTURE. THIS IS THEORETICALLY TRUE DOWN TO ABSOLUTE ZERO (-460 DEGREES FAHRENHEIT).

WHEN AIR HAS ABSORBED ALL THE MOISTURE VAPOR IT CAN HOLD IT IS SAID TO BE "SATURATED". ANY FURTHER ADDITION OF MOISTURE WOULD CAUSE CONDENSATION, OR THE VISIBLE PRESENCE OF WATER. AN EXAMPLE OF THIS IS WHAT WE CALL STEAM. ACTUALLY, THE MOISTURE VAPOR IS INVISIBLE, BUT THE EXCESS MOISTURE CREATED BY BOILING WATER APPEARS AS TINY DROPLETS OF MIST. IN WEATHER, THIS CONDENSATION OF MOISTURE IS CALLED "PRECIPITATION", AND IT APPEARS AS FOG, CLOUDS, RAIN, SNOW, ETC. THE TEMPERATURE AT WHICH SATURATED AIR BEGINS TO CONDENSE IS CALLED THE "DEW POINT".

RELATIVE HUMIDITY IS THE RATIO (GIVEN AS A PERCENTAGE) OF THE AMOUNT OF MOISTURE VAPOR IN THE AIR COMPARED TO THE AMOUNT OF MOISTURE VAPOR THE AIR IS CAPABLE OF ABSORBING AT THE SAME TEMPERATURE. A RELATIVE HUMIDITY OF 50% MEANS THE AIR IS ONLY HALF SATURATED; OR, IT INDICATES THE AIR COULD ABSORB TWICE AS MUCH MOISTURE.

AS AIR TEMPERATURES CHANGE, SO DO THE LIMITS OF SATURATION. AS PREVIOUSLY STATED, WARM AIR CAN HOLD MORE MOISTURE VAPOR THAN COLD AIR. WHEN WARM AIR WITH A HIGH RELATIVE HUMIDITY IS COOLED, THE RELATIVE HUMIDITY GOES UP. IF IT REACHES 100% (THE "DEW POINT"), THEN CONDENSATION OCCURS. THE FOLLOWING TABLE SHOWS THE "DEW POINT" TEMPERATURE FOR VARIOUS DRY-BULB TEMPERATURES AND RELATIVE HUMIDITY.*

Dew-Point Temperature, °F*

RH, %	Dry-bulb temperature, °F														
	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
100	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

*For intermediate, untabulated combinations of dry-bulb temperatures and RH, dew-point temperature can be interpolated on direct (i.e., linear) proportionality. For example, for 70°F, 35% RH interior temperature, dew point = (37 + 45)/2 = 41°F.

THE FLOW OF MOISTURE VAPOR IS IN RESPONSE TO VAPOR PRESSURE, WHICH IS DETERMINED BY TEMPERATURE AND RELATIVE HUMIDITY. MATHEMATICALLY, VAPOR PRESSURE INCREASES EXPONENTIALLY WITH INCREASES IN TEMPERATURE, BUT ONLY LINEARLY WITH INCREASING RELATIVE HUMIDITY.

THE FOLLOWING FIGURE SHOWS VAPOR PRESSURE GRADIENT CURVES. THE CO-ORDINATES (TEMPERATURE AND RELATIVE HUMIDITY) CAN BE LOCATED FOR BOTH THE INTERIOR CONDITIONS AND THE OUTSIDE AMBIENT CONDITIONS. WHEN THE ORDINATE (INTERSECTION) OF THE OUTSIDE AIR IS BELOW THE ORDIANTE OF THE INSIDE, THEN THE DIRECTION OF FLOW WILL BE (UPWARD). CONVERSERLY, IF THE OUTSIDE ORDINATE IS ABOVE THE INSIDE ORDINATE, THE FLOW DIRECTIN WILL BE <u>DOWNWARD</u>.

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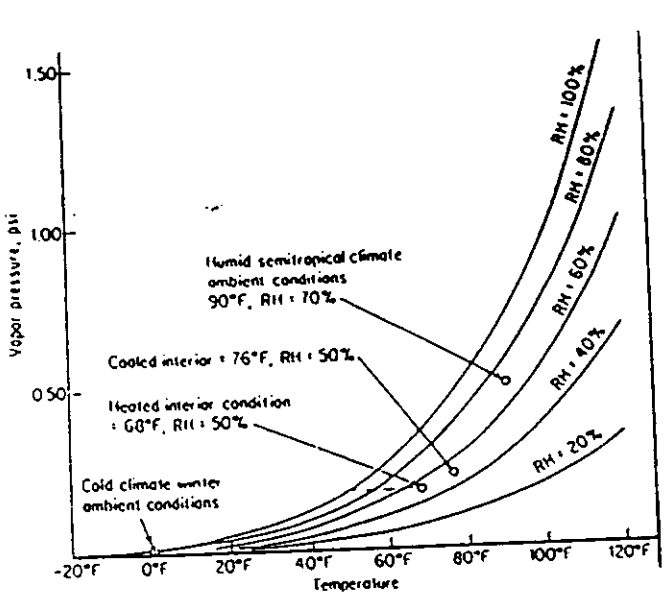
*C.W. GRIFFIN, "MANUAL OF BUILT-UP ROOF SYSTEM," SECOND EDITION, 1982 MCGRAW-HILL, INC., N.Y., N.Y.



This graph, which plots vapor pressure for a given temperature and relative humidity (RH), is a handy technique for determining the direction of water-vapor flow through a roof system. When the ordinate for outside ambient conditions is *below* the ordinate representing interior conditions, the vapor-flow direction is *upward*. [The vapor-pressure differential for a heated interior at 68°F, 50% RH with 0°F, 50% RH ambient, is about 0.16 psi.] Conversely, if the ordinate for outside ambient conditions is *above* the ordinate representing interior conditions, the vapor flows *downward*. [The downward vapor-pressure differential for a cooled interior at 76°F, 50% RH, with 90°F, 70% RH outside, is about 0.27 psi.]

THE NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA) RECOMMENDS THAT VAPOR RETARDERS BE CONSIDERED FOR USE WHEN BOTH OF TWO CONDITIONS ARE ANTICIPATED:

A) THE OUTSIDE MEAN, AVERAGE JANUARY TEMPERATURE IS BELOW 40 DEGREES FAHRENHEIT, AND

B) THE EXPECTED WINTER INTERIOR RELATIVE HUMIDITY IS 45% OR GREATER.

SOME EXPERTS FEEL THAT THIS APPROACH IS OVERSIMPLIFIED, AND SUGGEST THAT EVERY BUILDING SHOULD BE ANALYZED INDIVIDUALLY. SUCH ANALYSIS INVOLVES THE CALCULATION OF TWO TEMPERATURES: (1) THE TEMPERATURE AT THE VAPOR RETARDER LEVEL; AND (2) THE DEW-POINT TEMPERATURE. THE TEMPERATURE AT THE VAPOR RETARDER MUST REMAIN ABOVE THE DEW-POINT OR CONDENSATION WILL OCCUR.

SINCE CLIMATIC CONDITIONS ARE VARIABLE, MOISTURE VAPOR AND VAPOR PRESSURE ARE SUBJECT TO CONSTANT CHANGE. VAPOR RETARDERS, IF MISPLACED, CAN CAUSE PROBLEMS RATHER THAN PREVENT THEM. WITHOUT THOROUGH ANALYSIS OF THE ANTICIPATED TEMPERATURE AND DEW-POINT, THE BEST ADVISE IS "IF IN DOUBT, DON'T USE A VAPOR RETARDER."

WHEN VAPOR RETARDERS ARE USED, THEY SHOULD HAVE A PERMEANCE RATING BELOW 0.5 PERMS. ONE PERM ADMITS ONE GRAIN OF MOISTURE VAPOR PER SQUARE FOOT PER HOUR PER INCH OF MERCURY PRESSURE DIFFERENTIAL.

3. SELF-DRYING ROOF CONCEPT (5 MINUTES)

THE SELF-DRYING ROOF CONCEPT ASSUMES THAT THE HEAT OF SPRING AND SUMMER WILL EVAPORATE THE MOISTURE BUILD-UP OF FALL AND WINTER, AND FORCE THE MOISTURE VAPOR DOWNWARD INTO THE INTERIOR, WHERE IT CAN BE VENTED OUTDOORS.

RESEARCH AT THE NATIONAL BUREAU OF STANDARDS[1] CONFIRMS THE VALIDITY OF THE SELF-DRYING ROOF CONCEPT. WITHOUT INVOLVING COMPLEX MATHEMATICAL CRITERIA HERE, THE RECOMMENDATIONS OF THE RESEARCHERS ARE AS FOLLOWS.

A) VAPOR RETARDERS SHOULD NOT BE USED.

B) USE AT LEAST ONE MATERIAL WITH WATER-ABSORBING CAPACITY.

C) PROVIDE EDGE VENTING AND/OR MEMBRANE VENTING TO AVOID RAPID VAPOR-PRESSURE BUILDUP.

D) INSULATION SHOULD NOT EXCEED 4" IN THICKNESS

E) DO NOT USE A HIGHLY WATER-PERMEABLE INSULATION ALONE.

F) IF MORE THAN ONE INSULATING MATERIAL IS USED, LOCATE THE MATERIAL WITH THE LOWEST PERMEANCE DIRECTLY BELOW THE MEMBRANE.

G) LIMIT MAXIMUM INDOOR WINTER DEW-POINT TO 60 DEGREES FAHRENHEIT (THIS CORRESPONDS TO 80 DEGREES FAHRENHEIT WITH 50% RH).

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[1] FRANK J. POWELL AND HENRY E. ROBINSON, "THE EFFECT OF MOISTURE ON THE HEAT TRANSFER PERFORMANCE OF INSULATED FLAT ROOF CONSTRUCTION," BUILDING SCIENCE SERIES #37, NATIONAL BUREAU OF STANDARDS, 1971

C. SLOPE (5 MINUTES)

A 2% SLOPE (1/4" PER FOOT) SHOULD BE CONSIDERED AS AN ABSOLUTE MINIMUM FOR ROOF SURFACES, AND THIS SHOULD BE MAINTAINED AFTER ALL DEFLECTION HAS BEEN CALCULATED. WHEN DRAINAGE RUNS APPROACH 100', THE MINIMUM MAY BE INCREASED UP TO 1/2" PER FOOT. LONGER DRAINAGE RUNS SHOULD BE AVOIDED WHERE POSSIBLE, AS THE WATER TENDS TO FORM "SHEETS." THIS SHEETING ACTION WASHES AWAY GRAVEL, AND HAS A SCOURING EFFECT ON THE MEMBRANE.

ROOF SLOPES SHOULD BE BUILT INTO THE PERMANENT STRUCTURE, RATHER THAN BEING ACCOMPLISHED BY TAPERED INSULATION OR SLOPED POURED-IN-PLACE TOPPING. WHEN RE-ROOFING OR REMODELING EXISTING STRUCTURES, TAPERED INSULATION CAN BE USED TO PROVIDE THE DESIRED SLOPE. THIS IS USUALLY UNECONOMICAL IN NEW CONSTRUCTION.

SADDLES OR CRICKETS SHOULD BE USED TO PROVIDE POSITIVE DRAINAGE AROUND ANY OBSTACLES (SUCH AS CHIMNEYS, ROOF-TOP EQUIPMENT, ETC.) WHICH IMPEDE WATER FLOW. ALL ROOF SURFACES SHOULD PROVIDE SLOPE TOWARD THE DRAINS TO PREVENT PONDING. LOCATE INTERIOR ROOF DRAINS IN SUMPS, OR RECESSED SURFACES, TO INSURE POSITIVE FLOW. ALL DRAINS SHOULD BE LOCATED AT LOW POINTS IN THE ROOF SURFACE.

D. DRAINAGE (15 MINUTES)

ROOF DRAINAGE CAN BE ACCOMPLISHED BY INTERIOR OR PERIPHERAL DRAINS, OR A COMBINATION OF THE TWO. INTERIOR DRAINS ARE RECOMMENDED FOR COLD CLIMATES BECAUSE THE INTERIOR DRAIN PAIPES ARE LESS TROUBLESOME FROM FREEZING, BUT USUALLY REQUIRE MORE ELABORATE FLASHING TO PROTECT SCUPPERS AND GUTTERS. THE USE OF OVERFLOW SCUPPERS CAN PROVIDE A SAFETY VALVE FEATURE IN THE EVENT OTHER DRAINS BECOME CLOGGED.

THE LOCATION OF ROOF DRAINS SHOULD BE CAREFULLY COORDIANTED WITH ROOF SLOPES TO INSURE PROPER DISCHARGE OF THE WATER. FREQUENTLY ROOFS WILL HAVE

PONDING OF WATER IN LOW POINTS, YET INTERNAL ROOF DRAINS ARE HIGH AND DRY. STANDING WATER HAS A DELETERIOUS EFFECT ON THE MEMBRANE, AS WELL AS INCREASED POTENTIAL FOR LEAK DAMAGE. INTERNAL ROOF DRAINS ARE COMMONLY LOCATED NEAR INTERIOR COLUMNS FOR EASE OF RUNNING THE VERTICAL PIPING. DEFLECTION IN THE STRUCTURE IS MAXIMUM AT MIDSPAN, WITH NO DEFLECTION AT THE COLUMN. THUS, WITH DEFLECTION, THE WATER PONDS IN THE LOW AREAS WHILE THE DRAIN ITSELF IS HIGHER. THIS EMPHASIZES THE NEED TO DESIGN THE SLOPE INTO THE PERMANENT STRUCTURE, AND MAKE ALLOWANCE FOR DEFLECTION.

ROOF DRAINS MUST BE LOCATED AT THE LOW POINTS IN THE ROOF SURFACE IF THEY AE TO PERFORM THEIR FUNCTION. IT FOLLOWS THAT INTERIOR DRAINS SHOULD BE LOCATED NEAR MIDSPAN OF STRUCTURAL MEMBERS, WHERE DEFLECTION WILL BE MAXIMUM. THIS MAY REQUIRE HORIZONTAL PIPING TO CONNECT TO VERTICAL LEADERS, BUT THE ADDITIONAL COST WILL BE SLIGHT COMPARED TO REPLACEMENT RESULTING FROM PONDING. SOME SUGGESTED RULES FOR LOCATING INTERIOR DRAINS INCLUDE:

A) ALWAYS LOCATE DRAINS AT LOWEST POINTS IN THE ROOF, AND PROVIDE SUMP OR RECESSED AREA.

B) USE A MINIMUM OF TWO DRAINS FOR ROOFS LESS THAN 10,000 SQ. FEET.

C) LIMIT SPACING OF DRAINS TO 75' MAXIMUM, IN EACH DIRECTION.

D) PROVIDE ADDITIONAL DRAINS FOR IRREGULARY SHAPED ROOFS, SO THAT WATER FLOWS IN A STRAIGHT LINE.

E) PROVIDE SADDLES, OR CRICKETS, FOR WATER FLOW AROUND OBSTRUCTIONS.

F) EQUIP DRAINS WITH STRAINERS TO PREVENT CLOGGING OF LEADERS.

SIZING OF INTERIOR ROOF DRAINS REQUIRES THE DETERMINATION OF CONTRIBUTORY ROOF AREA (IN SQUARE FEET), THE RAINFALL INTENSITY (IN INCHES PER HOUR), AND THE SLOPE OF DRAIN PIPES (IN INCHES PER FOOT). A 1"/HR RAINFALL

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		
		¼	½	1
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

*Tabulated data from Josam Manufacturing Co.

PRODUCES A FLOW RATE OF 0.0104 GALLONS PER MINUTE (GPM) PER SQUARE FOOT (S.F.). THE FOLLOWING TABLE SHOWS THE FLOW RATE (IN GPM) FOR VARIOUS DIAMETER PIPES USED VERTICALLY AS LEADERS OR AS HORIZONTAL BRANCHES.

FOR EXAMPLE, IF ROOF DRAINS WERE SPACED 75' APART EACH WAY, THE CONTRIBUTORY AREA WOULD BE 75' x 75' = 5,625 S.F. IF WE ASSUME A LOCAL RAINFALL OF 3"/HR., THE FLOW RATE WOULD BE 5,625 x 3 x 0.0104 - 175.5 GPM. FROM THE TABLE WE CAN SEE THAT A 4" DIAMTER VERTICAL LEADER WOULD CARRY 192 GPM. NOW ASSUME THAT A HORIZONTAL DRAIN PIPE HAS A 1/4"/FT. SLOPE. FROM THE TABLE WE SEE THAT A 5" DIAMTER PIPE WOULD CARRY 197 GPM AT 1/4"/FT. SLOPE. SO THE ROOF DRAIN WOULD REQUIRE A 5" HORIZONTAL PIPE AND A 4" LEADER.

GUTTERS AND DOWNSPOUTS ARE FREQUENTLY USED FOR PERIPHERAL DRAINAGE, AND SHOULD BE SIZED FOR PROPER CAPACITY. TO SIZE GUTTERS, IT IS NECESSARY TO DETERMINE FOUR FACTORS: (1) THE TRIBUTARY ROOF AREA TO BE DRAINED (IN SQUARE FEET); (2) LOCAL RAINFALL INTENSITY (IN INCHES PER HOUR, FOR THE

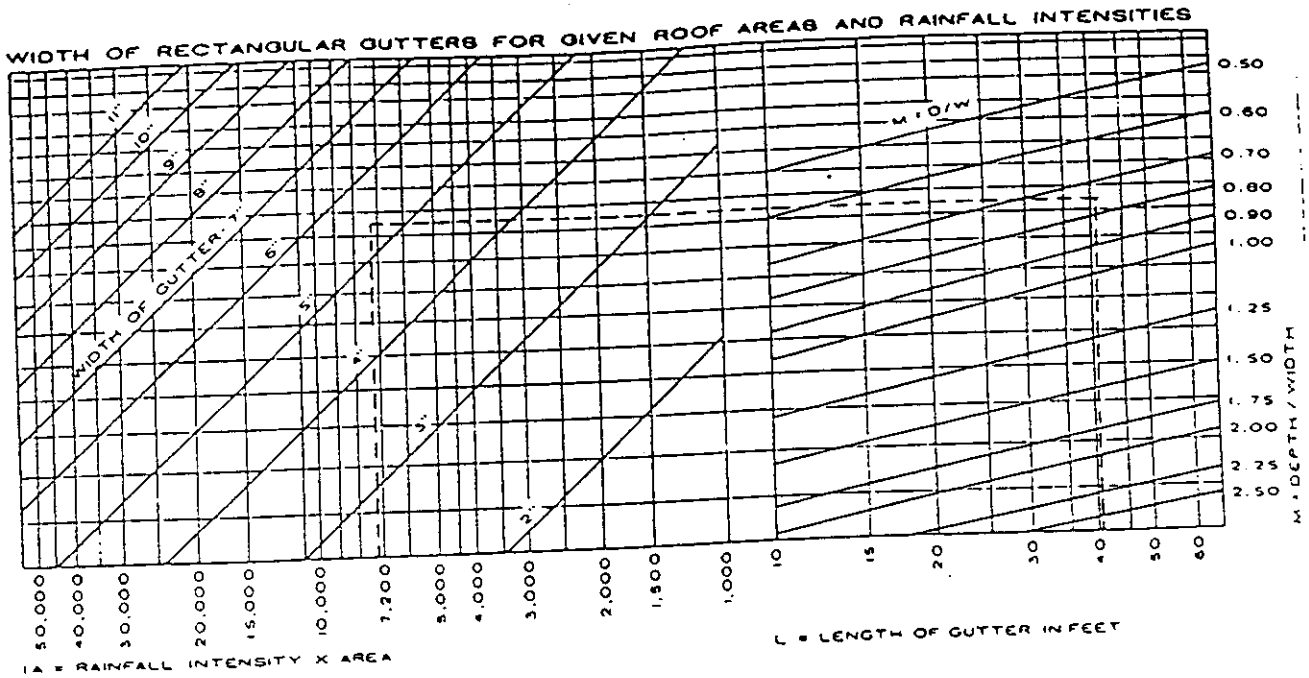
MOST INTENSE FIVE-MINUTE PERIOD TO BE EXPECTED IN TEN YEARS); (3) THE MAXIMUM LENGTH OF GUTTER (IN FEET); AND 94) THE RATIO OF GUTTER DEPTH TO WIDTH.

ON THE FOLLOWING PAGE IS A CHART FOR SIZING GUTTERS, WITH A TYPICAL EXAMPLE OF ITS USE. ALSO SHOWN IS A RAINFALL INTENSITY MAP, DOWNSPOUT CAPACITY, AND OTHER HELPFUL DATA.*

E. QUESTIONS AND ANSWERS (15 MINUTES)

*CHARLES G. RAMSEY AND HAROLD R. SLEEPER, "ARCHITECTURAL GRAPHIC STANDARDS," SIXTH EDITION, JOHN WILEY & SONS, INC. 1970.

Downspout and Gutter Sizing



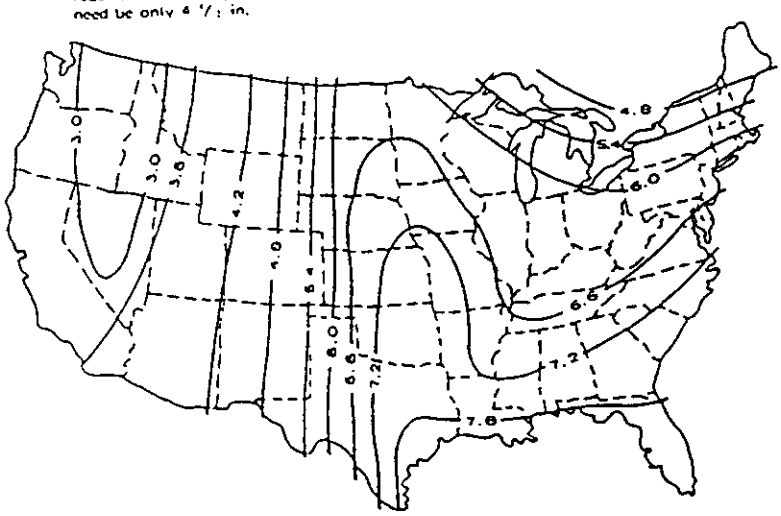
SAMPLE PROBLEM:

To size rectangular gutter for a building 120 x 30 ft. located in New York City. This building has a flat roof with a raised roof edge on three sides. A gutter is to be located on one of the 120 ft. sides. So that each section of gutter will not exceed 50 ft., three downspouts will be used with 2 gutter expansion joints. The area to be drained by each section of gutter will be 1200 sq. ft., the rainfall intensity from map below is 6 in., the length of each gutter section is 40 ft., and the ratio of gutter depth to width is 0.75. On chart above find the vertical line representing L = 40. Proceed vertically along this line to its intersection with the oblique line representing M = 0.75. Pass horizontally to the left to intersect the vertical line representing IA = 7200. The point of intersection occurs between the oblique line representing gutter widths of 5 and 6 in. The required width of gutter is, therefore, 6 in. and its depth need be only 4 $^{1}/_{2}$ in.

DESIGN AREAS FOR PITCHED ROOFS

PITCH	FACTOR
LEVEL TO 3 IN./FT.	1.00
4 TO 5 IN./FT.	1.05
6 TO 8 IN./FT.	1.10
9 TO 11 IN./FT.	1.20
12 IN./FT.	1.30

NOTE: When a roof is sloped neither the plan nor actual area should be used in sizing drainage. Multiply the plan area by the factor shown above to obtain design area.



RAINFALL INTENSITY MAP

NOTE:

Map shows hourly rainfall in inches for 5 minute periods to be expected once in 10 yrs. This is normally adequate for design but record storms have gone twice as high in some areas. For important work see local records.

DOWNSPOUT CAPACITY

INTENSITY IN IN./HR. LASTING 5 MIN.	SQ. FT. ROOF/SQ. IN. DOWNSPOUT
2	600
3	400
4	300
5	240
6	200
7	175
8	150
9	130
10	120
11	110

GENERAL NOTES:

Most gutters are run level for appearance. However, a slope of $^{1}/_{16}$ in. per foot is desirable for drainage.

For residential work allow 100 sq. ft. of roof area per 1 sq. in. of downspout.

LESSON PLAN 3

1. SUBJECT: ROOF DESIGN

2. OBJECTIVES: TO PROVIDE OVERVIEW OF THE BASIC COMPONENTS OF BUILT-UP ROOFING MEMBRANES

3. LESSON OUTLINE:

SUBJECT	TIME REQUIRED
MATERIALS	5 MINUTES
BITUMENS	5 MINUTES
ASPHALT BITUMEN	15 MINUTES
COAL TAR BITUMEN	10 MINUTES
FELTS	10 MINUTES
CEMENTS	5 MINUTES
ROOF SURFACES	3 MINUTES
AGGREGATE SURFACING	3 MINUTES
SMOOTH SURFACING	3 MINUTES
MINERAL SURFACING	3 MINUTES
PROTECTIVE/REFLECTIVE COATING	3 MINUTES
BUILT-UP MEMBRANE	15 MINUTES
QUESTIONS AND ANSWERS	15 MINUTES
TOTAL	110 MINUTES

4. TRAINING AIDS:

A. 35mm SLIDE PROJECTOR

B. OVERHEAD PROJECTOR

C. SCREEN

FIRST DAY - LESSON 3

1:00 - 2:50

ROOF DESIGN MANUAL

FUNDAMENTALS OF PITCH & ASPHALT MEMBRANES

A. MATERIALS (5 MINUTES)

MEMBRANES ARE BUILT UP OF SEVERAL LAYERS (OR PLIES) 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.

1. BITUMENS (5 MINUTES)

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, KEROSENE 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 YHELLOW-GREEN AND IS TRANSPARENT, THE BITUMEN IS PITCH.

A) ASPHALT BITUMEN (15 MINUTES)

ASPHALT BITUMEN USED FOR ROOFING IS ONE OF THE LAST STAGES IN THE PROCESSING OF CRUDE OIL. REFINERIES REMOVE THE LIGHT DISTILLATES (GASO-

LINES) AND HEAVY DISTILLATES (DIESEL FUELS, AVIATION FUEL AND HEATING OILS) FROM CRUDE OIL, LEAVING PAVING ASPHALT AND ASPHALT FLUX. THE ASPHALT FLUX IS THEN PROCESSED IN A BLOWSTILL, WHERE IT IS HEATED AND SUBJECTED TO AIR INJECTION -- CALLED "BLOWING". THE END RESULT IS ASPHALT ROOFING BITUMEN, AND THE TEMPERATURE OF THE ASPHALT DURING THIS FINAL BLOWING PROCESS IS THE "FINISHED BLOWING TEMPERATURE", OR FBT. IF ASPHALT IS LATER HEATED ABOVE THIS FINISHED BLOWING TEMPERATURE FOR MORE THAN FOUR HOURS, IT MAY EFFECT THE SOFTENING POINT TEMPERATURE, AND EVEN ITS APPROPRIATE USES.

THE TEMPERATURE RANGE AT WHICH ASPHALT SOFTENS, OR MELTS, IS CALLED THE "SOFTENING POINT", OR SP. THE TEMPERATURE AT WHICH ASPHALT MAY BURST INTO FLAME IS CALLED THE "FLASH POINT", OR FP.

STUDIES HAVE SHOWN THAT ASPHALTS HAVING A VISCOSITY OF 100 - 150 CENTI-STOKES HAVE OPTIMUM WETTING AND ADHESIVE PROPERTIES FOR ROOFING. THE TEMPERATURE AT WHICH AN ASPHALT ATTAINS THIS TARGET VISCOSITY OF 125 CENTI-STOKES IS CALLED THE "EQUIVISCOUS TEMPERATURE", OR EVT. THIS IDEAL TEMPERATURE MAY VARY FROM ONE ASPHALT TO ANOTHER, BUT SHOULD BE LISTED BY THE MANUFACTURER. ASPHALT BITUMENS ARE CLASSIFIED INTO FOUR TYPES:

TYPE I <u>DEAD LEVEL ASPHALT</u>: THIS ASPHALT TENDS TO FLOW AT ROOF TEMPERATURES, HAS GOOD ADHESION AND SELF-HEALING QUALITIES. IT IS GENERALLY USED ON AGGREGATE-SURFACED ROOFS WITH SLOPES UP TO 1/2" PER FOOT.

TYPE II <u>FLAT ASPHALT</u>: THIS HAS MODERATE FLOW AT ROOF TEMPERATURES, AND IS GENERALLY USED ON ROOF SLOPES OF 1/2" PER FOOT TO 1 1/2" PER FOOT.

TYPE III <u>STEEP ASPHALT</u>: THIS IS NOT SUSCEPTIBLE TO FLOW AT ROOF TEMPERATURE, AND IS GENERALLY USED ON SLOPES BETWEEN 1" PER FOOT AND 3" PER FOOT.

TYPE IV SPECIAL STEEP ASPHALT: THIS IS LEAST SUSCEPTIBLE TO FLOW AT ROOF TEMPERATURES, OR HOT CLIMATES, AND IS USED ON SLOPES BETWEEN 2" PER FOOT AND 6" PER FOOT.

ASPHALTS USED FOR ROOFING SHOULD MEET OR EXCEED THE REQUIREMENTS OF ASTM STANDARD D-312, FOR TYPE I, II, III OR IV. IN ADDITION, THE MANUFACTURERS LABEL SHOULD SET FORTH THE SOFTENING POINT (SP), THE FLASH POINT (FP), THE FINISHED BLOWING TEMPERATURE (FBT), AND THE EQUIVISCOUS TEMPERATURE (EVT). THE FOLLOWING TABLES LIST SOME OF THESE TEMPERATURES.

Type No.	Kind of Asphalt	Softening Point Min.	Softening Point Max.	Maximum Heating Temperature
Type I	Dead Level Asphalt	135° F	151° F	475° F
Type II	Flat Asphalt	158° F	176° F	500° F
Type III	Steep Asphalt	185° F	205° F	525° F
Type IV	Special Steep Asphalt	210° F	225° F	525° F

B) COAL TAR BITUMEN (10 MINUTES)

COAL TAR BITUMEN, OR "PITCH", HAS BEEN SUCCESSFULLY USED AS A ROOFING MATERIAL FOR OVER A CENTURY. THERE ARE ONLY A LIMITED NUMBER OF MANUFACTURERS, AND THE PRODUCT VARIATIONS ARE LESS THAN FOR ASPHALT. THE "EQUIVISCOUS TEMPERATURE" CONCEPT HAS NOT BEEN APPLIED TO PITCH, ALTHOUGH IT WOULD BE APPLICABLE. COAL TAR BITUMEN IS CLASSIFIED INTO THREE TYPES:

TYPE I COAL-TAR PITCH: USED FOR BUILT-UP ROOFS USING COAL-TAR SATURATED FELTS.

TYPE II WATERPROOFING PITCH: USED FOR DAMPPROOFING AND MEMBRANE WATERPROOFING BELOW GRADE, OR ON PLAZA DECKS USING COAL-TAR SATURATED FELTS.

TYPE III COAL-TAR BITUMEN: USED IN BUILT-UP ROOFS, AND HAS A SLIGHTLY HIGHER SOFTENING POINT THAN TYPE I.

COAL-TAR BITUMEN USED FOR ROOFING SHOULD MEET OR EXCEED THE REQUIREMENTS OF ASTM STANDARD D-450, FOR TYPES I, II AND III. HEATING AND APPLICATION TEMPERATURES FOR COAL-TAR BITUMENS ARE SLIGHTLY LOWER THAN THOSE FOR ASPHALT BITUMENS. MOST MANUFACTURERS RECOMMEND A KETTLE TEMPERATURE OF 425 DEGREES F, BUT SLIGHTLY HIGHER TEMPERATURES MAY BE USED TO ATTAIN THE PROPER MOPPING VISCOSITY. HOWEVER, TEMPERATURE ABOVE 425 DEGREES F SHOULD NOT BE MAINTAINED FOR MORE THAN FOUR HOURS.

2. FELTS (10 MINUTES)

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 FELTS:

ORGANIC FELTS ARE MADE OF WOOD FIBERS, WASTE PAPER, OR RAGS.

ASBESTOS FELTS ARE MADE OF ASBESTOS FIBERS, WITH SOME ORGANIC FIBERS.

GLASS FELTS ARE MADE OF INTERWOVEN STRANDS OF GLASS FIBERS.

ORGANIC AND ASBESTOS FIBERS AR AVAILABLE IN PERFORATED OR UNPERFORATED ROLLS. PERFORATED FELTS ARE FOR GENERAL BUILT-UP ROOFING, AND CONTAIN LINES (OR PLY MARKINGS) FOR TWO, THREE OR FOUR LAYERS. UNPERFORATED FELTS ARE

USED FOR SHINGLE UNDERLAYMENT, AS A GENERAL BUILDING PAPER, OR FOR BUILT-UP ROOFING MEMBRANES.

THERE ARE ALSO SPECIAL PURPOSE FELTS. "BASE SHEETS" ARE HEAVIER WEIGHT FELTS USED AS THE BASE, OR FIRST PLY. "COATED FELTS" ARE OFTEN SPECIFIED AS BASE SHEETS, FOR USE WITH COLD MASTIC APPLIED ROOFING, FOR SMOOTH SURFACE ROOFS, OR AS VAPOR RETARDERS. "VENTING BASE SHEETS" ARE SOMETIMES USED AS AN UNDERLAYMENT OR BASE PLY OVER DAMP OR POURED-IN-PLACE DECKS TO ALLOW VENTING OF MOISTURE VAPOR PRESSURE. "MINERAL SURFACED FELTS" ARE OFTEN USED AS CAP SHEETS, AS VENTING SHEETS, AS FINISH ROOFING (ROLL ROOFING), AND AS BASE FLASHING.

3. CEMENTS (5 MINUTES)

CEMENTS USED IN ROOFING ARE ROOFING CEMENT AND FLASHING 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.

4. ROOF SURFACES (3 MINUTES)

SURFACING MATERIALS PROTECT THE BITUMEN AND FELT MEMBRANE FROM DIRECT SUNLIGHT AND WEATHER EXPOSURE. THEY MAY ALSO PROVIDE OTHER PROPERTIES. THERE ARE FOUR COMMON SURFACING OPTIONS: AGGREGATE SURFACING; SMOOTH SURFACING; MINERAL SURFACING; AND PROTECTIVE/REFLECTIVE COATING. THESE ARE DISCUSSED IN THE FOLLOWING.

A) AGGREGATE SURFACING (3 MINUTES)

AGGREGATES OF GRAVEL, CRUSHED STONE, OR CINDERS ARE EMBEDDED IN A FLOOD COAT OF BITUMEN ON TOP OF THE MEMBRANE. ADVANTAGES OF AGGREGATE SURFACING INCLUDE: ULTRA-VIOLET PROTECTION, WIND-UPLIFT RESISTANCE, FIRE RESISTANCE, STABLIZING OF FLOOD COAT BITUMEN, PROTECTS AGAINST PUNCTURE, AND HELPS STABILIZE AGAINST TEMPERATURE FLUCTUATIONS.

AGGREGATE SHOULD BE OPAQUE AND NOMINALLY 3/8" DIAMETER WITHOUT SHARP EDGES OR CORNERS. ASTM STANDARD D-1863 GIVES THE FOLLOWING GRADATION REQUIREMENTS.

Type of Sieve	Percent of Aggregate Passing through Sieve
3/4" Sieve	100%
1/2" Sieve	85% - 100%
3/8" Sieve	35% - 70%
#4 Sieve	0 - 20%
#8 Sieve	0 - 10%

B) SMOOTH SURFACING (3 MINUTES)

MEMBRANE SURFACE IS FINISHED WITH TOP COATING OF HOT ASPHALT-SOMETIMES CALLED "GLAZE COATING." THIS IS NOT AS SATISFACTORY AS AGGREGATE SURFACING, AND IS NOT RECOMMENDED FOR GENERAL USE. NRCA SUGGESTS ITS USE WHEN AGGREGATE SURFACING IS IMPRACTICAL, SUCH AS WHEN SLOPE EXCEEDS 3" PER FOOT, OR WHERE AIR INTAKE OR EXHAUST EQUIPMENT CAUSES CONCERN OVER LOOSE GRAVEL.

C) MINERAL SURFACING (3 MINUTES)

A PREPARED MINERAL-SURFACED CAP SHEET IS HOT-MOPPED AS A FINAL LAYER OVER A MULTI-PLY BUILT-UP ROOF MEMBRANE. PERHAPS BETTER THAN SMOOTH SURFACING, IT IS NOT RECOMMENDED AS AN EQUAL TO AGGREGATE SURFACING. SOME RUBBERIZED CAP SHEETS HAVE PERFORMED SATISFACTORILY.

D) PROTECTIVE/REFLECTIVE COATING (3 MINUTES)

THIS SYSTEM INVOLVES THE APPLICATION OF A PROTECTIVE AND/OR REFLECTIVE COATING OVER A SMOOTH SURFACED BUILT-UP ROOF. A VARIETY OF COATINGS PROVIDE VARIOUS PROPERTIES, FROM REFLECTIVE ALUMINUM COLOR TO COAL-TAR BASED MASTIC USED AS ADHESIVE FOR MINERAL GRANULES. SOME COATINGS MAY BE APPLIED BY BRUSHING, SPRAYING OR TROWELING.

B. APPLICATION

1) <u>ROOF DECKS</u> (15 MINUTES)

THE FOLLOWING GUIDELINES ARE GIVEN FOR INSTALLATION OF ROOF DECKS.

A) JOINTS OF INSULATION BOARDS SHOULD PROVIDE MODERATE CONTACT WHERE PIECES BUTT TOGETHER.

B) INSULATION BELOW A BUILT-UP MEMBRANE SHOULD BE IN TWO LAYERS, WITH ALL JOINTS OFFSET BETWEEN UPPER AND LOWER LAYERS.

C) WHERE POSSIBLE, THE BOTTOM LAYER OF INSULATION SHOULD BE MECHANICALLY FASTENED, AND THE SECOND LAYER ATTACHED BY HOT MOPPING.

D) INSTALLATION OF INSULATION SHOULD BE COORDINATED WITH MEMBRANE APPLICATION SO THAT THE INSULATION IS COVERED WITH ROOFING PROMPTLY.

2) BUILT-UP MEMBRANE (15 MINUTES)

THE FOLLOWING GUIDELINES ARE GIVEN FOR APPLICATION OF BUILT-UP MEMBRANES.

A) THE FIRST PLY, OR BASE SHEETS, MUST BE SECURELY ATTACHED TO THE SUBSTRATE. OVER INSULATION OR NON-NAILABLE DECKS, HOT STEEP ASPHALT SHOULD BE USED. ON NAILABLE DECKS, THE FIRST PLY SHOULD BE MECHANICALLY FASTENED.

B) ROOFING PLYS SHOULD START AT THE LOWEST POINTS IN THE ROOF, AND SHINGLE UPWARD WITH PROPER LAPS.

C) FELTS SHOULD RUN IN STRAIGHT LINES, IN FULL MOPPINGS OF HOT BITUMEN; AND EACH PLY SHOULD BE BROOMED TO RELEASE ENTRAPPED AIR AND AID IN BONDING.

D) THE TEMPERATURE OF THE BITUMEN SHOULD BE WITHIN THE EVT RANGE AT THE POINT OF APPLICATION.

E) ALL PLIES SHOULD BE INSTALLED THE SAME DAY. IF AGGREGATE SURFACING IS TO BE DELAYED, THE MEMBRANE SHOULD BE GIVEN A GLAZE COAT OF BITUMEN.

F) THE PRACTICE OF PHASED APPLICATION BETWEEN PLIES IS NOT RECOMMENDED.

G) ALL ACCESSORY ITEMS AND FLASHINGS SHOULD BE INSTALLED BEFORE THE APPLICATION OF AGGREGATE. AGGREGATE SHOULD BE EVENLY SPREAD INTO A FLOOD COAT OF HOT BITUMEN.

QUESTION AND ANSWER: (15 MINUTES)

LESSON PLAN 4

1. SUBJECT: ROOF DESIGN

2. OBJECTIVES: TO PROVIDE OVERVIEW OF FLASHINGS AND SHEET METAL DETAILS

3. LESSON OUTLINE:

SUBJECT	TIME REQUIRED
INTRODUCTION	15 MINUTES
FLASHING DETAILS	80 MINUTES
QUESTIONS AND ANSWERS	15 MINUTES
TOTAL	110 MINUTES

4. TEACHING AIDS:

   A. 35mm SLIDE PROJECTOR

   B. OVERHEAD PROJECTOR

   C. SCREEN

FIRST DAY - LESSON 4

3:10 - 5:00

ROOF DESIGN MANUAL

PENETRATIONS, FLASHING & SHEET METAL

INTRODUCTION (15 MINUTES)

FLASHINGS ARE A FREQUENT CAUSE OF ROOFING LEAKS, AND THESE ARE OFTEN DUE TO FAULTY DETAILS. IT HAS BEEN SAID THAT "TO PROPERLY DESIGN FLASHING, ONE MUST LEARN TO THINK LIKE A DROP OF WATER." THERE IS CERTAINLY AN ELEMENT OF TRUTH THERE, BECAUSE WATER SEEMS TO PENETRATE IN UNEXPECTED WAYS.

THERE ARE STANDARD DETAILS AVAILABLE FOR MOST FLASHING SITUATIONS. MANY OF THESE HAVE BEEN USED SUCCESSFULLY FOR YEARS. CROSS-SECTION VIEWS SHOW HOW CAP FLASHING OVERLAPS BASE FLASHING; HOW CAP FLASHING FITS INTO REGLETS; HOW THRU-WALL FLASHING SHOULD BE INSTALLED IN MASONRY PARAPETS; AND HOW GRAVEL-STOPS ARE BONDED WITH THE ROOFING MEMBRANE. ONE PROBLEM WITH THESE DRAWINGS, HOWEVER, IS THAT THE METAL FLASHING IS NOT ONE CONTINUOUS PIECE. ANY CONTINUOUS FLASHING MUST BE MADE UP BY LAP SPLICING STANDARD LENGTHS. AND WHAT HAPPENS WHEN TWO PARAPET WALLS INTERSECT WITH METAL COPING ON EACH? WHERE IS THE END OF THE GRAVEL STOP? TOO OFTEN THE FLASHING DETAILS DO NOT INDICATE WHAT HAPPENS AROUND THE CORNER, OR WHEN TWO FLASHINGS MEET. NOR DO THEY CLEARLY SHOW HOW METAL COPINGS ARE FASTENED; HOW OFTEN; OR HOW THE LAP IS TO BE ACCOMPLISHED. DRAFTSMEN OFTEN SAY "LET THE ROOFER FIGURE IT OUT." OMISSIONS IN FLASHING DETAILS ARE OFTEN THE CAUSE OF MISUNDERSTANDINGS AND EVEN LITIGATION.

ANOTHER COMMON PROBLEM IN METAL FLASHING IS THE USE OF DIFFERENT METALS. WHEN TWO DISSIMILAR METALS COME IN CONTACT, IN THE PRESENCE OF AN ELECTROLYTE (SUCH AS WATER), A GALVANIC CORROSION CALLED "ELECTROLYSIS" IS LIKELY TO OCCUR. IN SUCH GALVANIC CORROSION ONE METAIL WILL DISINTEGRATE. WHEN DISSIMILAR METALS ARE USED IN FLASHING, THEY MUST BE ISOLATED (SO THEY DO NOT COME IN CONTACT WITH EACH OTHER), OR THEY MAY BE INSULATED FROM EACH OTHER BY A NON-CONDUCTIVE MATERIAL (SUCH AS ROOFING FELT OR MASTIC).

FLASHING DETAILS: (80 MINUTES.)

FLASHINGS ARE USED WHERE THE BUILT-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 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 3).

D) "COPINGS" ARE METAL PIECES PLACED ON TOP OF WALLS TO COVER THE WALL AND ANY BASE FLASHING ON THE WALL. (SEE FIGURE 4).

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 OVER THE MEMBRANE AND SECURELY ANCHORED. THEN TWO PLIES OF FELT STRIPS ARE MOPPED OVER THE FLANGE. THE TOP OF THE CYLINDER, OR "BOOT", IS TURNED DOWN INSIDE THE PIPE.

AN ALTERNATIVE FLASHING FOR VENT PIPES IS TO USE A SHEET METAL "BOOT" WITH THE FLANGE SET SIMILAR TO THE LEAD BOOT ABOVE. THE TOP OF THE SHEET METAL CYLINDER, HOWEVER, IS CAPPED BY AN UMBRELLA-LIKE FLASHING, WHICH IS TIGHTENED AROUND THE PIPE WITH A DRAWBAND AND CAULKED. (SEE FIGURE 5)

F) "THRU-WALL FLASHING" IS A SHEET METAL FLASHING USED TO PREVENT WATER PENETRATION THRU 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 7)

G) "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 8)

H) "PITCH PANS" HAVE BEEN 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 ONTO THE MEMBRANE, AND STRIP-MOPPED OVER THE FLANGE. INSIDE THE BOX IS FILLED WITH TYPE I HOT ASPHALT OR PITCH. (SEE FIGURE 6)

PITCH PANS ARE NOT RECOMMENDED FOR USE EXCEPT IN CIRCUMSTANCES WHERE OTHER FLASHING IS IMPRACTICAL (SUCH AS GUY WIRES). THE USE OF FLASHING SIMILAR TO THE "ALTERNATIVE VENT FLASHING" MENTIONED IN (3) ABOVE IS RECOMMENDED IN LIEU OF PITCH PANS.

I) "ROOF DRAINS" ARE DRAIN 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 9)

J) "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 10)

K) "GUTTERS" ARE HORIZONTAL SHEET METAL TROUGHS WHICH COLLECT WATER RUNNING OVER THE EDGE OF A ROOF. THESE SLOPE SLIGHTLY TO DRAIN INTO A VERTICAL PIPE, CALLED A "DOWNSPOUT" OR "LEADER". THE BOTTOM END OF THE DOWNSPOUT USUALLY EXTENDS INTO A STORM WATER COLLECTOR SYSTEM, OR TURNS OUTWARD TO DISCHARGE THE RAINWATER ONTO A "SPLASH BLOCK" OR OTHER SUITABLE SURFACE, OR INTO A STORM WATER COLLECTOR SYSTEM, TO PREVENT WASHING OUT OF THE SOIL. (SEE FIGURE 11)

QUESTIONS AND ANSWERS: (15 MINUTES)

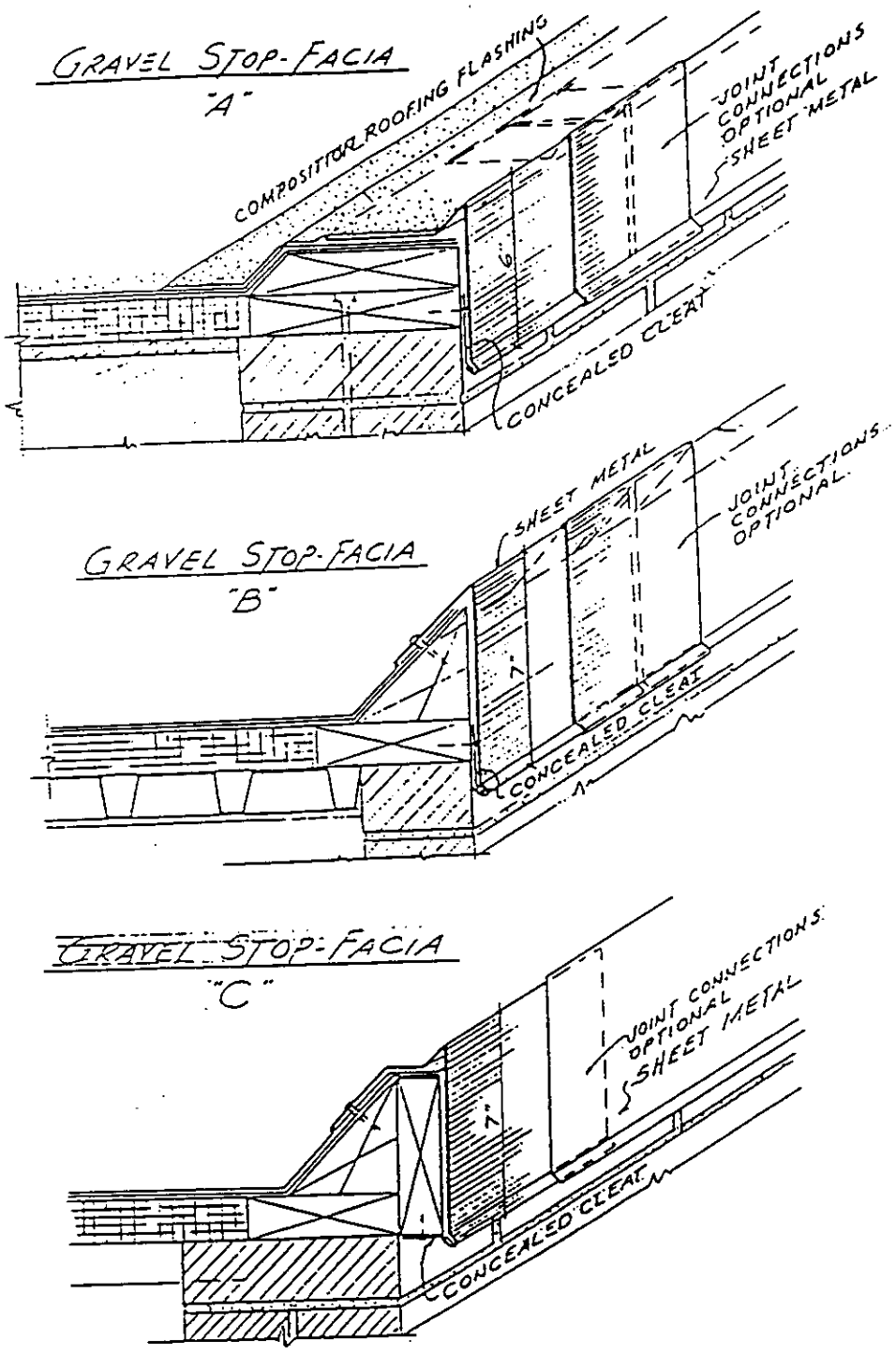


FIGURE 1*

*Chicago Roofers' Joint Apprenticeship Committee, "Roofers' Apprentice Training Manual."

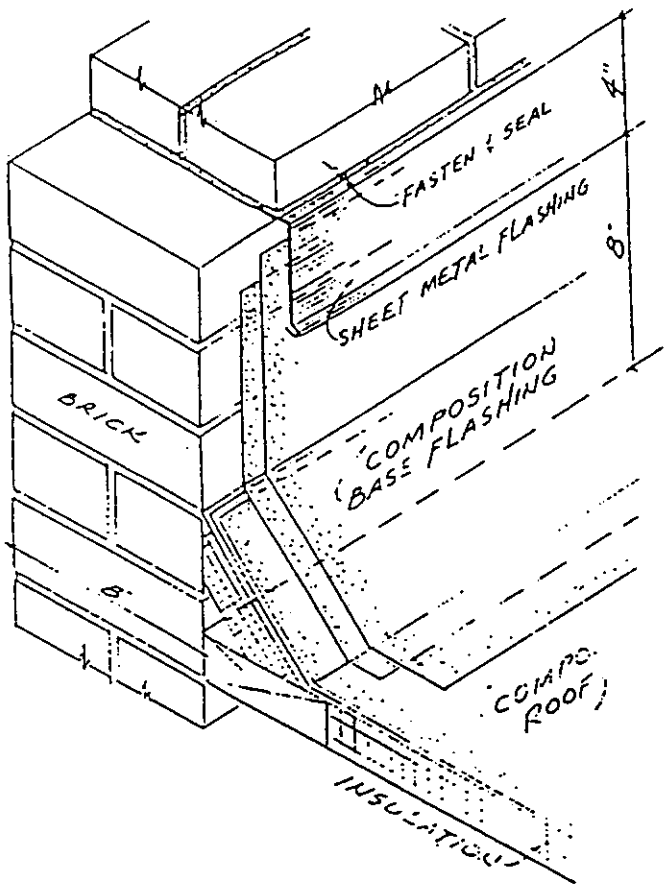


FIGURE 2*

*Chicago Roofers' Joint Apprenticeship Committee, "Roofers' Apprentice Training Manual."

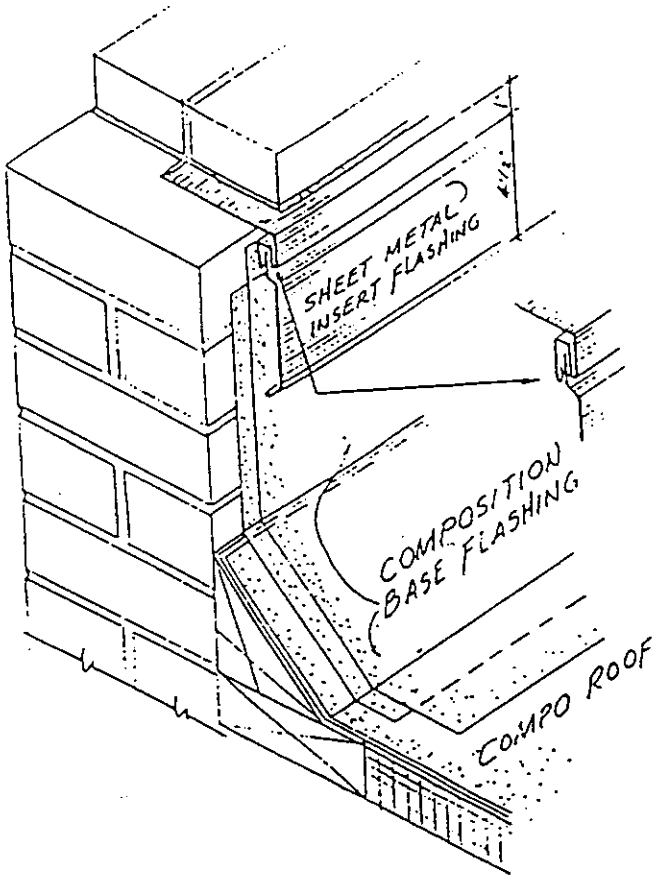


FIGURE 3*

*Chicago Roofers' Joint Apprenticeship Committee, "Roofers' Apprentice Training Manual."

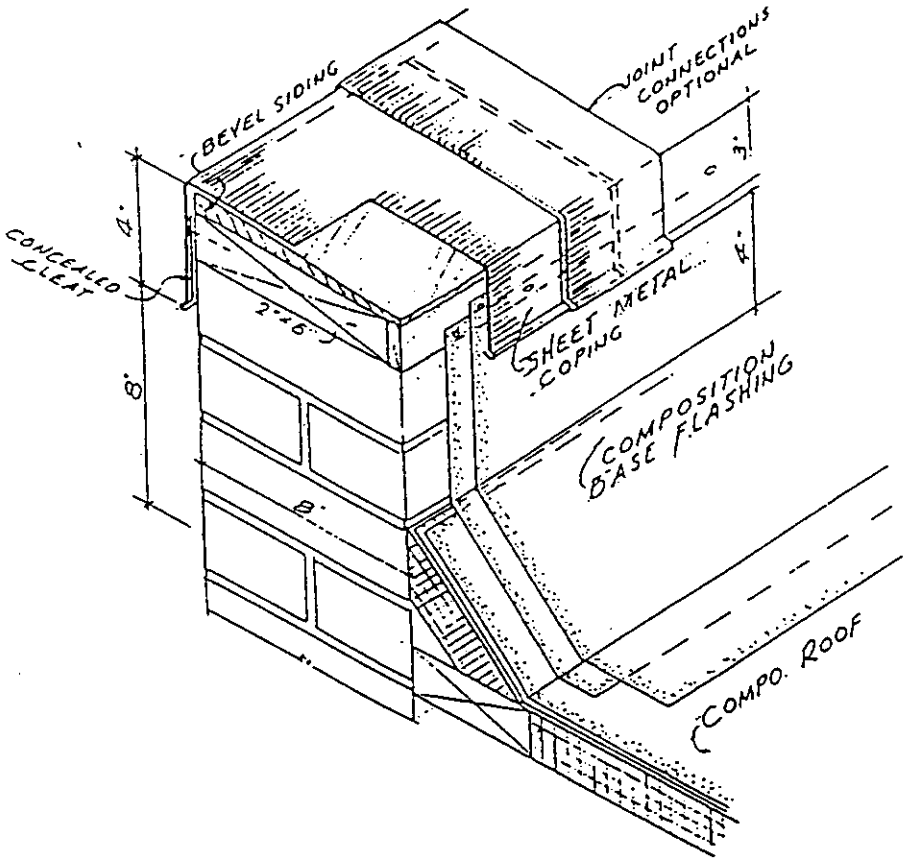


FIGURE 4*

*Chicago Roofers' Joint Apprenticeship Committee, "Roofers' Apprentice Training Manual."

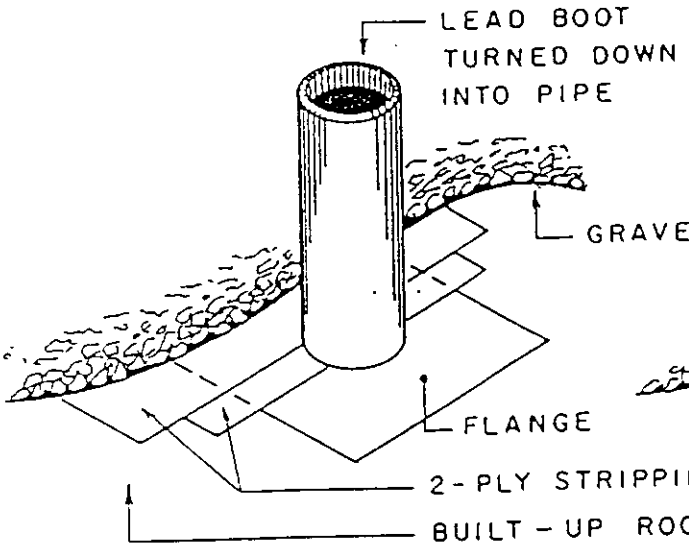


FIGURE 5

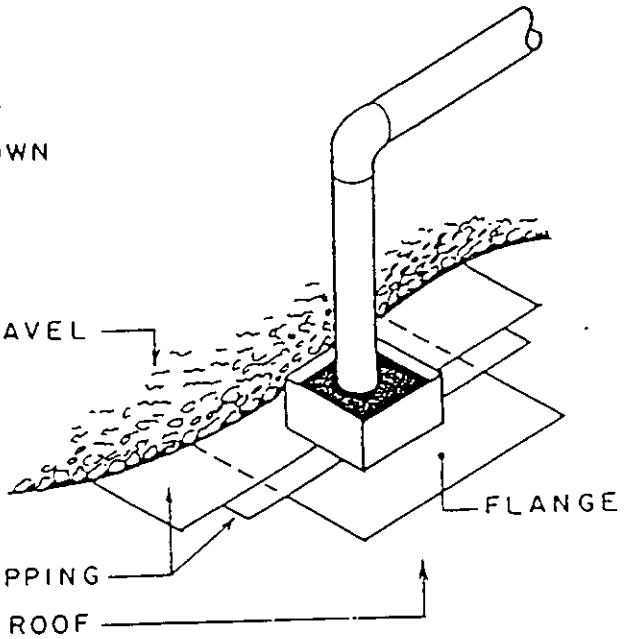


FIGURE 6

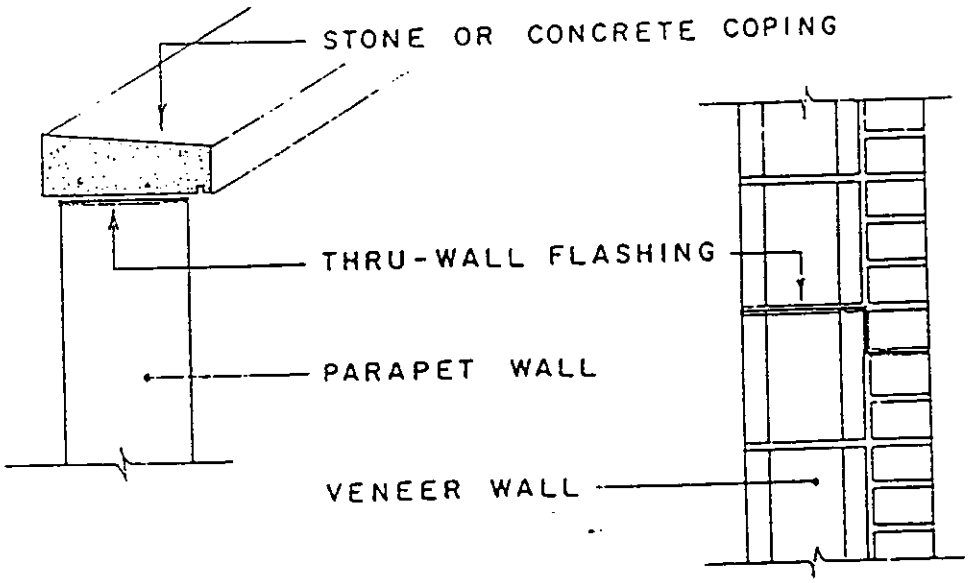
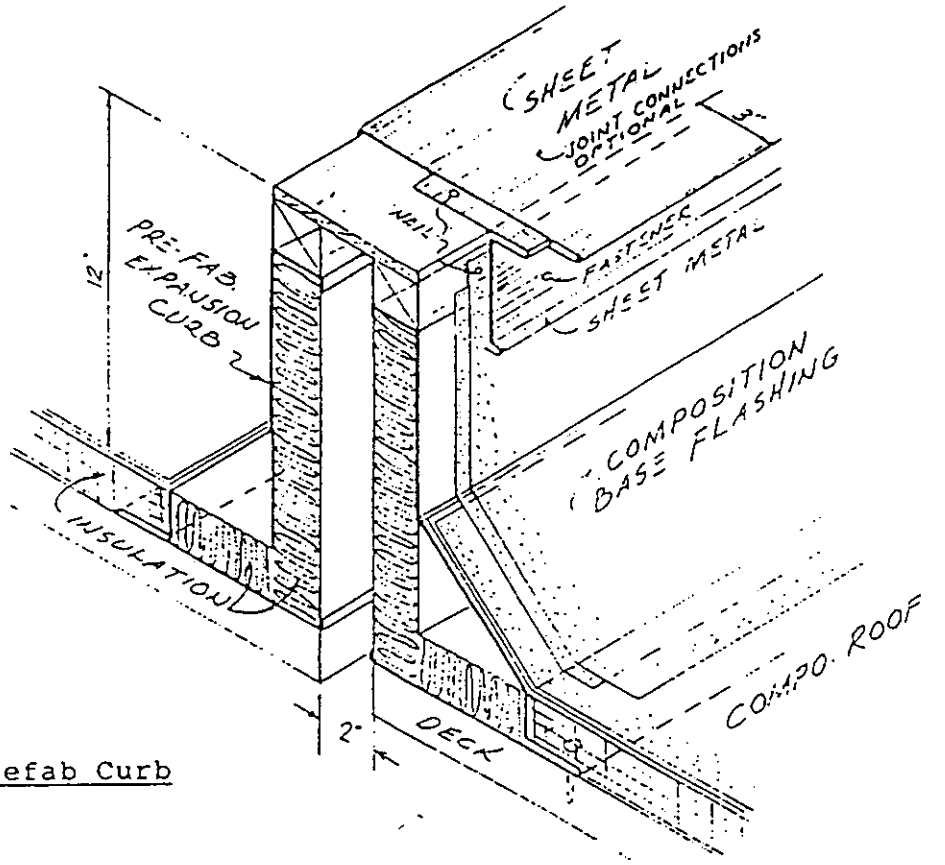
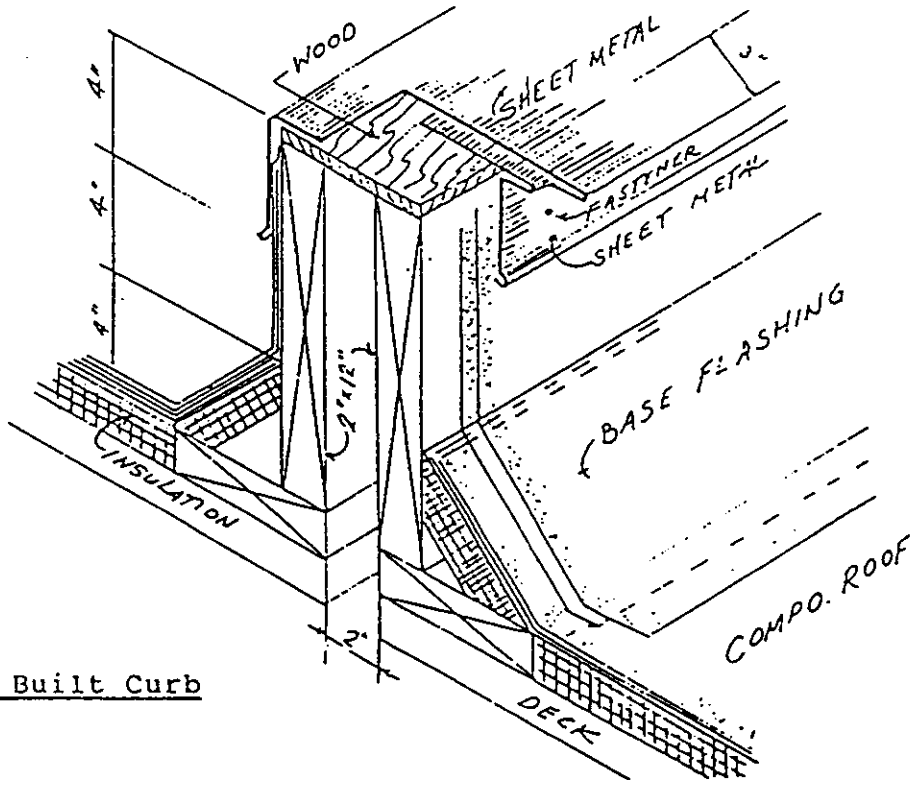


FIGURE 7



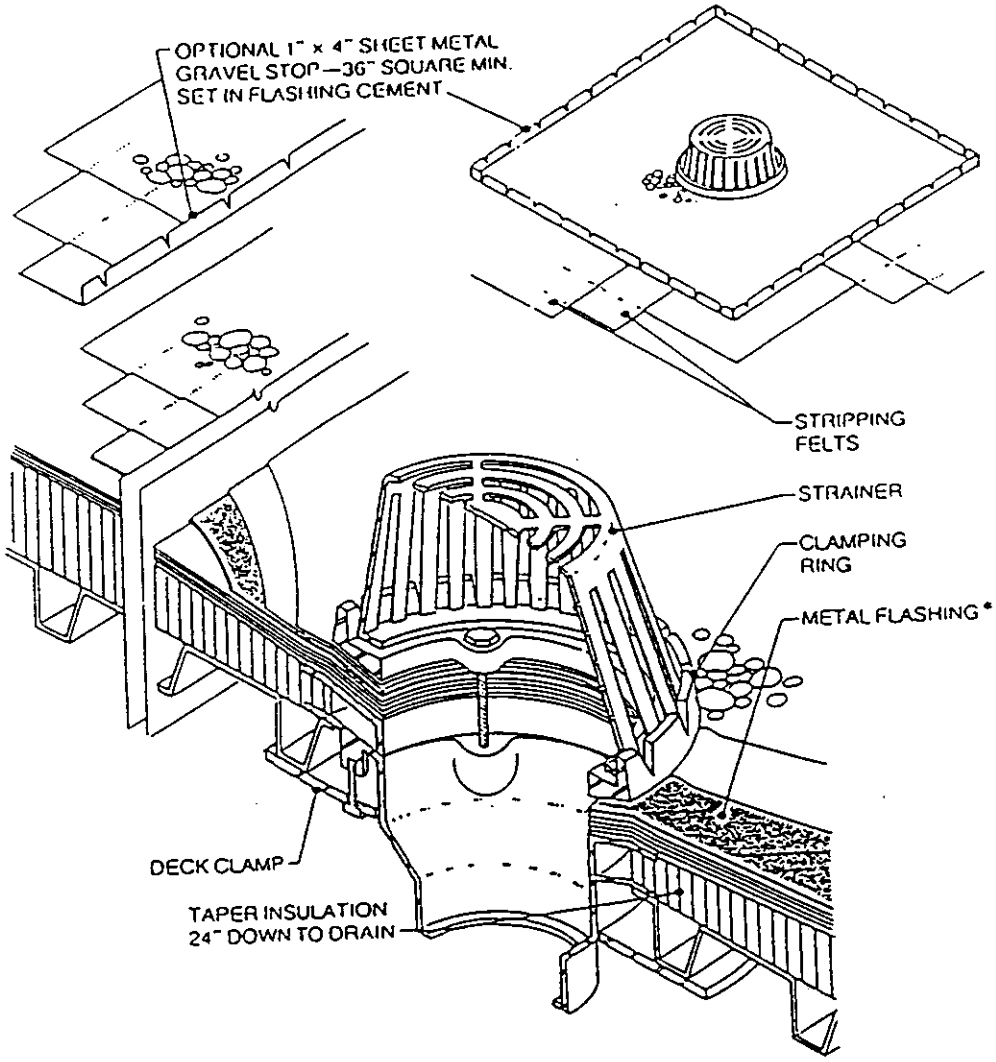
Prefab Curb



Job Built Curb

FIGURE 8*

*Chicago Roofers' Joint Apprenticeship Committee, "Roofers' Apprentice Training Manual."



NOTES:

*MIN. 30" SQUARE, 2½ LB. TO 4 LB. LEAD OR 16 OZ. SOFT COPPER FLASHING, SET ON FINISHED ROOFING FELTS IN MASTIC. PRIME TOP SURFACE BEFORE STRIPPING.

MEMBRANE PLIES, METAL FLASHING, AND FLASH-IN PLIES EXTEND UNDER CLAMPING RING.

STRIPPING FELTS EXTEND 4" AND 6" BEYOND EDGE OF FLASHING SHEET.

FIGURE 9*

*National Roofing Contractors Association "Manual of Roofing and Waterproofing."

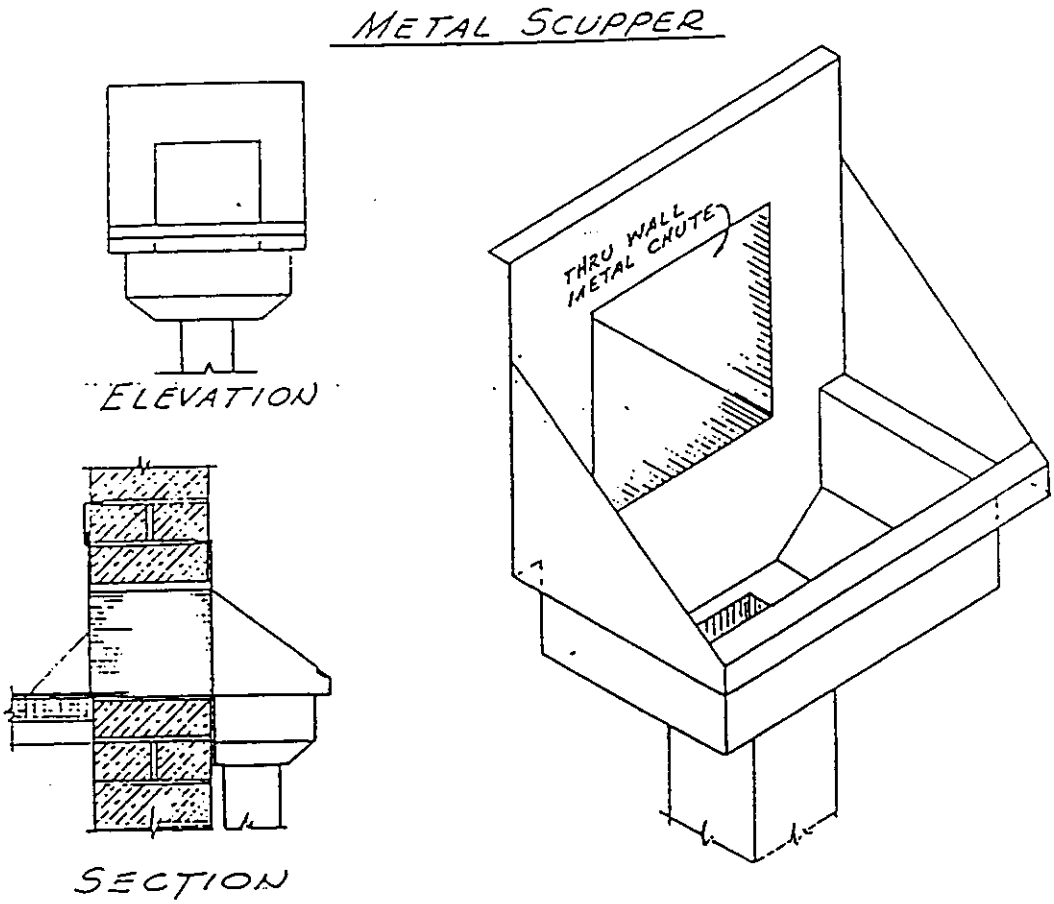


FIGURE 10*

*Chicago Roofers' Joint Apprenticeship Committee, "Roofers' Apprentice Training Manual."

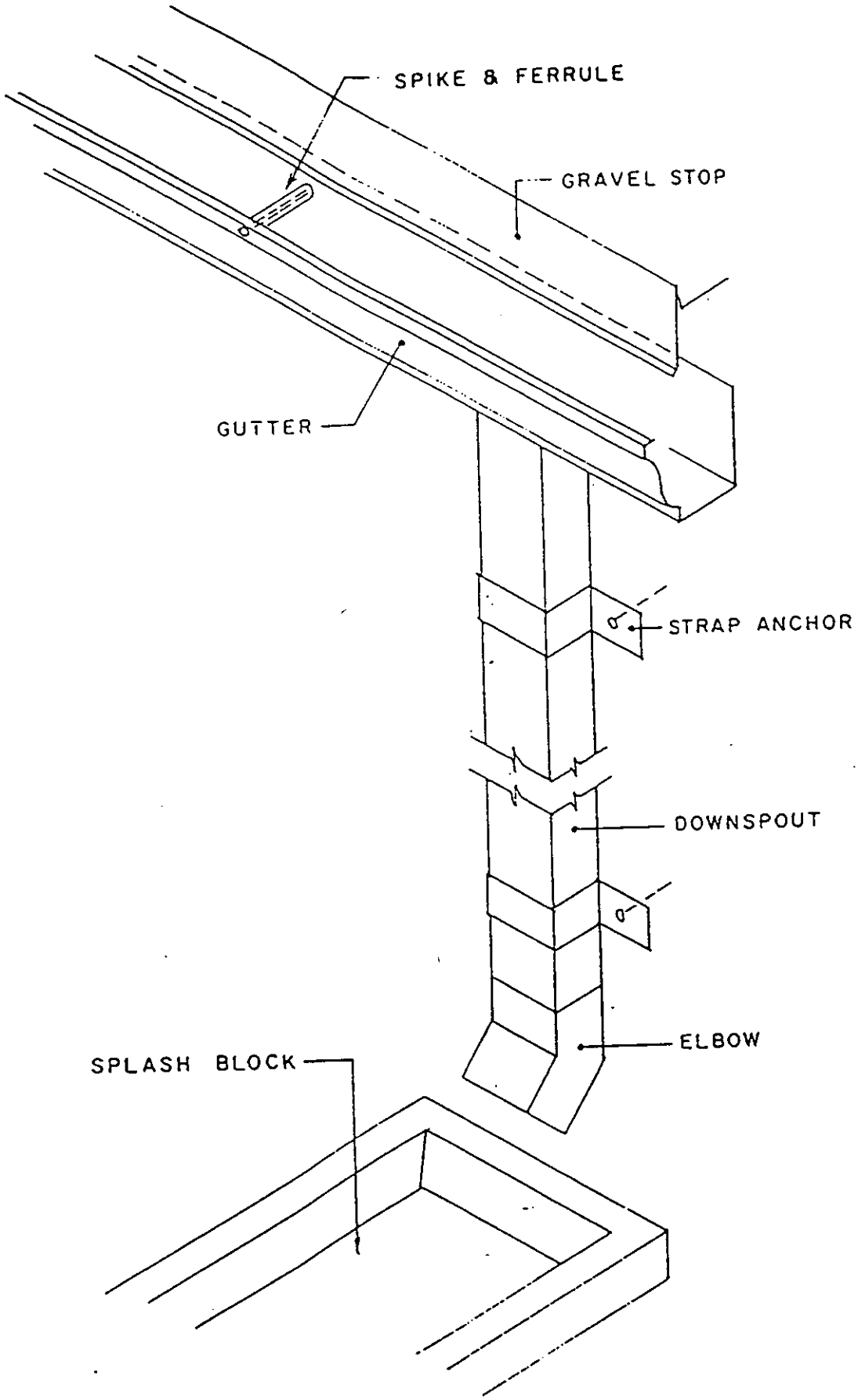
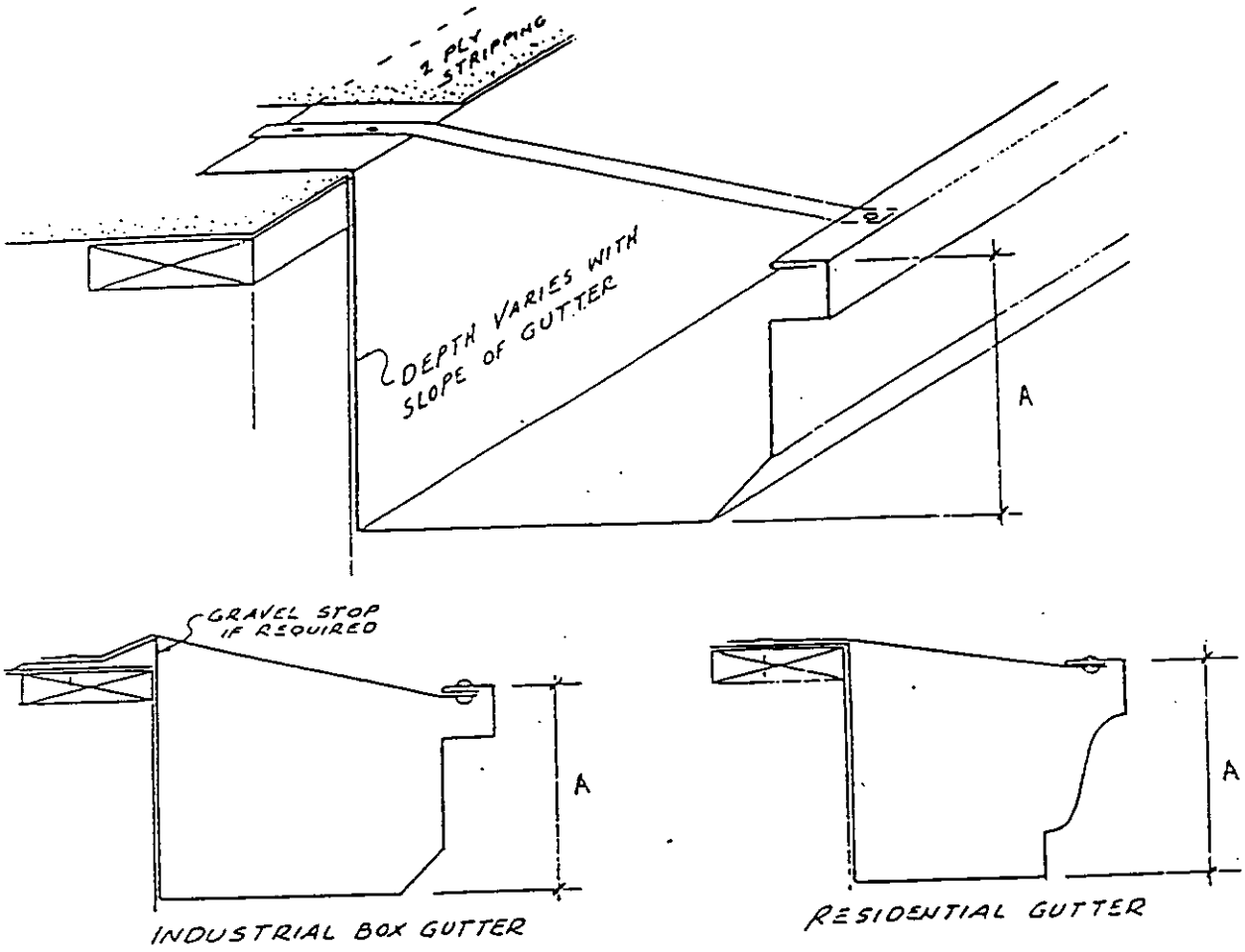

SPIKE & FERRULE
GRAVEL STOP
GUTTER
STRAP ANCHOR
DOWNSPOUT
ELBOW
SPLASH BLOCK

FIGURE 11



RECOMMENDED MINIMUM GAUGES
FOR FASCIA SHOWN ABOVE

EXPOSED FACE WITHOUT BRAKES "A" DIMENSION	GALVANIZED IRON	COLD ROLLED COPPER	ALUMINUM 3003-H14
UP TO 6" FACE	26 GA.	16 OZ.	.040" (18 GA.)
6" TO 8" FACE	24 GA.	16 OZ.	.050" (16 GA.)
8" TO 10" FACE	22 GA.	20 OZ.	.064" (14 GA.)
10" TO 15" FACE	20 GA.	ADD BRAKES TO STIFFEN	.080" (12 GA.)

FIGURE 12

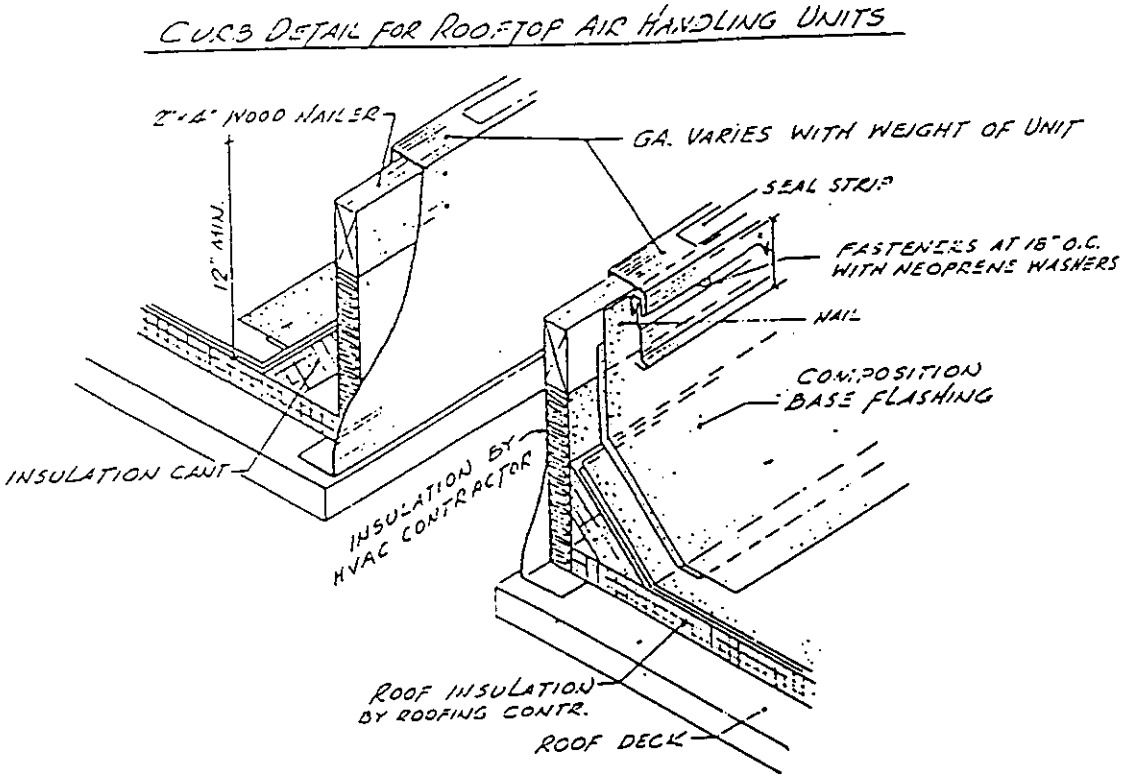


FIGURE 13*

*Chicago Roofers' Joint Apprenticeship Committee, "Roofers' Apprentice Training Manual."

PRE-FAB METAL CURBS

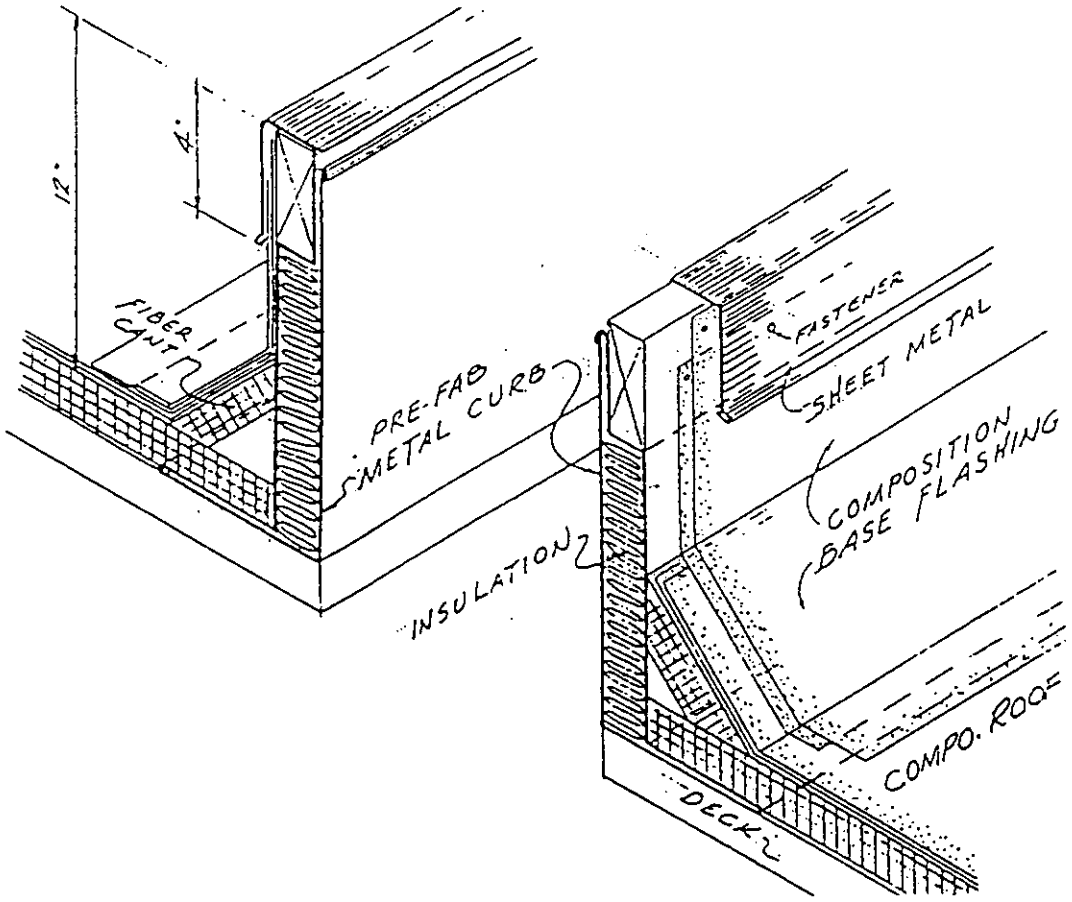


FIGURE 14*

*Chicago Roofers' Joint Apprenticeship Committee, "Roofers' Apprentice Training Manual."

LESSON PLAN 5

1. SUBJECT: QUALITY CONTROL INSPECTIONS

2. OBJECTIVES: TO PROVIDE GUIDELINES FOR INSPECTIONS AND ADMINISTRATION OF ROOF INSTALLATION

3. LESSON OUTLINED:

SUBJECT	TIME REQUIRED
INTRODUCTION	5 MINUTES
PRECONSTRUCTION CONFERENCE	15 MINUTES
RECORD KEEPING	5 MINUTES
INSPECTION EQUIPMENT	5 MINUTES
SAFETY	10 MINUTES
INSPECTION OF ROOF DECKS	20 MINUTES
INSPECTION OF MEMBRANE APPLICATION	20 MINUTES
INSPECTION OF FLASHING AND DRAINAGE	15 MINUTES
QUESTIONS AND ANSWERS	15 MINUTES
TOTAL	110 MINUTES

4. TRAINING AIDS:

A. 35mm SLIDE PROJECTOR

B. OVERHEAD PROJECTOR

C. SCREEN

SECOND DAY - LESSON 5

8:00 - 9:50

QUALITY CONTROL INSPECTIONS

INTRODUCTION (5 MINUTES)

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.

QUALITY CONTROL INSEPCTION SHOULD 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 EARLY ENOUGH TO BE CORRECTED WITHOUT COSTLY DELAYS. INSPECTION IS PARTICULARLY IMPORTANT WHEN ROOFING CONTRACTS ARE AWARDED ON THE BASIS OF LOW BIDS.

PRECONSTRUCTION CONFERENCE (15 MINUTES)

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 A GOOD RAPPORT.

THE FOLLOWING POINTS SHOULD BE INCLUDED IN A PRECONSTRUCTION CONFERENCE.

1. 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.

2. LOCATION FOR STORING MATERIALS ON THE SITE, AND THE PROPER IDENTIFICATION OF THOSE MATERIALS. ROOFING FELTS MUST BE PROTECTED FROM THE WEATHER, AND SHOULD BE STORED ON END ABOVE THE GROUND LEVEL. COVERING WITH PLASTIC SHEETING IS NOT RECOMMENDED, AS CONDENSATION FORMS ON THE UNDERSIDE OF THE PLASTIC.

3. PROTECTION OF THE OWNERS PROPERTY MUST BE PROVIDED. HEATING KETTLES MAY BE A CAUSE OF SEVERE DAMAGE, AND HANDLING OF HOT BITUMEN MAY INVOLVE LEAKAGE. GROUND COVER PROTECTION SHOULD BE REQUIRED UNDER KETTLES IF THE SITE HAS ALREADY BEEN DEVELOPED. ANY EXISTING BUSHES OR SHRUBS SHOULD BE ADEQUATELY PROTECTED.

4. 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.

5. PROPER HANDLING OF MATERIALS TO THE ROOF SHOULD BE DISCUSSED. HOISTING EQUIPMENT OR CRANES REQUIRE SOME ADVANCE PLANNING, AS THEY INVOLVE BOTH SAFETY AND PROPERTY PROTECTION.

6. PROPER DISPOSAL OF TRASH AND DEBRIS SHOULD BE AGREED UPON. ALL ROOFING OPERATIONS INVOLVE WASTE MATERIALS; RE-ROOFING OR MAJOR REPAIRS GENERALLY INVOLVE THE REMOVAL OF OLD ROOFING, INSULATION AND GRAVEL. HOW THESE MATERIALS ARE TO BE DISPOSED OF MUST BE A CONCERN. ENCLOSED CHUTES OR COVERED CONTAINERS ARE RECOMMENDED WHERE NECESSARY. GOOD HOUSEKEEPING SHOULD BE REQUIRED THROUGHOUT THE OPERATION.

7. SANITARY FACILITIES SHOULD BE PROVIDED. WHOSE RESPONSIBILITY IS THIS? THE GENERAL CONTRACTOR, THE SUBCONTRACTOR, OR THE OWNER MAY AT VARIOUS TIMES PROVIDE THIS NECESSARY FACILITY.

8. FINALLY, ALL MATERIALS AND METHODS SPECIFICATIONS SHOULD BE THOROUGHLY UNDERSTOOD. ANY CHANGES FROM THOSE SPECIFICATIONS MUST BE APPROVED IN WRITTEN CHANGE ORDER FORM. ALL ROOF BONDS AND WARRANTY PERIODS SHOULD BE CLEARLY ESTABLISHED.

RECORD KEEPING (5 MINUTES)

A HISTORICAL RECORD SHOULD BE SET UP AND MAINTAINED FOR EACH ROOF FROM THE TIME THE ROOF IS INSTALLED. ROOF PLANS AND ALL RELATED CONTRACT DATA SHOULD BE INCLUDED IN THIS FILE. ALL INSPECTIONS SHOULD BE RECORDED ON REPORT FORMS, AND FOLLOW-UPS MADE TO INSURE THAT CORRECTIVE ACTION HAS BEEN DONE. THE USE OF INSPECTION REPORT FORMS WILL SAVE TIME, MAINTAIN UNIFORMITY, AND PROVIDE A CHECK-LIST TO REDUCE THE CHANCE OF OVERLOOKING ITEMS.

PHOTOGRAPHS ARE VALUABLE VISUAL RECORDS AND SHOULD BE USED TO ACCOMPANY AND SUPPLEMENT INSPECTION REPORTS. CAMERAS WHICH PROVIDE "INSTANT DEVELOPING" ARE RECOMMENDED, AS THEY GIVE IMMEDIATE RESULTS. OTHER CAMERAS MAY BE BETTER IF CLARITY OF DETAIL, ENLARGEMENTS, SLIDES OR MULTIPLE COPIES ARE DESIRED.

INSPECTION EQUIPMENT (5 MINUTES)

THE FOLLOWING TOOLS AND EQUIPMENT ARE RECOMMENDED FOR ROOF INSPECTIONS.

A) CLIPBOARD, PAPER, REPORT FORMS, PENCILS, ETC.

B) MOISTURE METER

C) HEAT GUN (NON-CONTACT INFRARED THERMOMETER)

D) CAMERA AND FILM

SAFETY (10 MINUTES)

EXTREME CAUTION MUST BE EXERCISED WHEN WORKING ON ROOFS, AND INSPECTORS SHOULD INSIST UPON GOOD SAFETY PROCEDURES BY ALL WORKERS INVOLVED IN THE OPERATION. LADDERS SHOULD BE STURDY, FIRMLY SET AT THE BASE, AND SECURELY TIED OFF AT THE TOP, AND EXTEND 3" BEYOND TOP OF ROOF. MATERIALS AND EQUIPMENT SHOULD BE HOISTED UP — NOT CARRIED UP THE LADDER.

HOT BITUMEN IS EXTREMELY HAZARDOUS. KETTLES AND HOISTING OR PUMPING EQUIPMENT SHOULD BE CHECKED REGULARLY FOR TEMPERATURES AND GENERAL CONDITION. OPERATIONS INVOLVING POWER TOOLS MAY PRESENT SAFETY PROBLEMS, AND SHOULD BE OBSERVED CLOSELY.

INSPECTION OF ROOF DECKS (20 MINUTES)

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 BE DESIGNED INTO THE STRUCTURE, BUT MAY BE ACCOMPLISHED BY TAPERED THICKNESSES OF INSULATION. CHECK FOR EXPANSION JOINTS ANYWHERE THE DECK MATERIAL CHANGES, OR THE DIRECTION OF THE DECK MATERIAL CHANGES.

SOME OF THE MOST COMMON TYPES OF DECKS ARE OUTLINED IN THE FOLLOWING.

A) WOOD DECKS

ALTHOUGH SOLID BOARDS ARE SELDOM USED IN NEW WORK, THEY MAY BE ENCOUNTERED IN RE-ROOFING OR REPAIR WORK. THE SAME PRECAUTIONS APPLY AS WITH PLYWOOD. DUE TO SHRINKAGE, SWELLING, AND WARPING, NAILS OFTEN TEND TO WITHDRAW. FOR THIS REASON CARE SHOULD BE EXERCISED IN APPLYING BUILT-UP ROOFING DIRECTLY OVER WOOD DECKS. IT IS RECOMMEND-

ED THAT INSULATION BE USED OVER THE WOOD DECKS. THIS INSULATION SHOULD BE IN TWO LAYERS; THE FIRST MECHANIALLY FASTENED AND THE SECOND MOPPED DIRECTLY TO A WOOD DECK.

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 HAVE SOME ACOUSTICAL QUALITIES AS WELL. IT IS RECOMMENDED THAT THEY BE TREATED BASICALLY THE SAME AS WOOD, EXCEPT WILL REQUIRE SPECIAL FASTENERS.

C) STEEL DECKS

STEEL DECKS ARE HEAVY GAUGE SHEET METAL ROLLED INTO CORRUGATIONS TO PROVIDE STRUCTURAL PANELS. THESE PANELS ARE USUALLY TACK-WELDED (USING WELDING WASHERS) TO A STEEL STRUCTURAL SYSTEM TO PROVIDE A PLATFORM, OVER WHICH RIGID INSULATION IS APPLIED TO FORM THE DECK. SEVERAL RECOMMENDATIONS ARE OFFERED FOR THESE DECKS.

1. CHECK WELDS SECURING THE STEEL DECK. MAKE SURE WELDING WASHERS ARE USED, AND THAT 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 THE APPLICATION OF THE INSULATION UNEVEN.

3. PROVIDE "EXPANSION JOINTS" IN THE ROOF WHENEVER 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 FASTENING, AND THE SECOND LAYER BEING APPLIED WITH HOT BITUMEN, WITH THE JOINTS STAGGERED.

D. PRESTRESSED CONCRETE DECKS

PRECAST, PRESTRESSED CONCRETE DECKS OFFER ADVANTAGES, AND ARE QUITE POPULAR; HOWEVER, THERE ARE STILL SOME MAJOR CONCERNS WITH THIS DECK.

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 REDUCED BY JACKING THEM INTO ALIGHMENT, 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. THE MOST COMMON SOLUTION IS TO MERELY GROUT THE UNEVEN JOINTS. SUCH GROUTING SHOULD BE EXTENDED OVER A WIDE ENOUGH AREA SO THAT THE SLOPE 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 BE CHECKED FOR MOISTURE IMMEDIATELY BEFORE THE APPLICATION OF INSULATION OR ROOF MEMBRANE. THEY MUST BE DRY (10% OR LESS MOISTURE) BEFORE PROCEEDING.

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 ARE EXAMPLES. SINCE SOME OF THESE NON-NAILABLE DECKS (OR QUESTIONALBE AT BEST), THE MEMBRANE BASE SHEE SOMETIMES MUST BE HOT MOPPED TO THE DECK, OR OVER A PRIMER. THE PRESENCE OF ANY MOISTURE MEANS A POOR BOND AND THE LIKELIHOOD OF FORMING BLISTERS. THEREFORE, A TWO-LAYER RIGID INSULATION IS RECOMMENDED OVER NON-NAILABLE DECKS, SOMETIMES WITH ROOF RELIEVE VENTS TO ALLOW ANY RESIDUAL MOISTURE TO EXCAPE WITHOUT CAUSING BLISTERS OR RIDGES.

INSPECTION OF MEMBRANE APPLICATION (20 MINUTES)

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 AND TEMPERATURE, AS WELL AS 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 IMPROPER VARIATION, WITHOUT WRITTEN APPROVAL, SHOULD BE REJECTED.

B) CHECK TO BE SURE THE APPROPRIATE BASE SHEET IS USED, AND THAT THE PROPER METHOD OF ATTACHMENT (NAILING OR MOPPING) IS USED.

C) MAKE SURE THAT 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) CAN BE DIVIDED INTO THE WIDTH OF THE ROLL (USUALLY 36") TO GIVE THE NUMBER OF PILES. FOR EXAMPLE, AN OFF-SET ANOMINAL DISTANCE OF 9: DIVIDED INTO 36" = 4 PLIES.

D) 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 IS THE "HEAT GUN", OR HAND HELD INFRARED THERMO- METER THAT CAN BE POINTED AT A NEARBY SURFACE AND INDICATES THE TEMPERATURE. BITUMEN TEMPERATURE MUST BE CAREFULLY CONTROLLED. ASPHALT SHOULD BE AT EVT (EQUIVISCOUS TEMPERATURE) PLUS OR MINUS 25 DEGREES F AT THE POINT OF APPLICATION. KETTLE TEMPERATURES SHOULD STAY BELOW FP (FLASH POINT) AND NOT EXCEED FBT (FINISHED BLOWING TEMPERATURE) FOR MORE THAN FOUR HOURS.

E) 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.

F) 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.

G) GRAVEL AGGREGATES SHOULD BE EMBEDDED IN A "FLOOD COAT" OF HOT BITUMEN -- WHERE BITUMEN IS POURED OUT RATHER THAN BEING MOPPED ON.

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 FASHING:
   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 _____
   ARE THEY WELL SEALED? _____YES _____NO
   ARE THEY AT LOW POINTS? _____YES _____NO

DRAINAGE SYSTEM (CONT'D)

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 REPONSIBLE FOR SAFETY IN ROOFING OPERATION? (NAME OF PERSON)
   _____

2. ARE SAFETY MEASURES ADEQUATE? ____YES ____NO
   IF NO, WHAT ACTIONS SHOULD BE TAKEN? _____
   _____

LESSON PLAN 6

1. SUBJECT: QUALITY CONTROL INSPECTIONS

2. OBJECTIVES: TO PROVIDE FIELD INSPECTION EXPERIENCE OF ROOF INSTALLATION

3. LESSON OUTLINED:

SUBJECT	TIME REQUIRED
FIELD TRIP TO INSPECT ROOF INSULATION	110 MINUTES

SECOND DAY - LESSON 6

10:10 - 12:00

FIELD TRIP TO INSPECT ROOF INSTALLATION

THIS IS A FIELD TRIP TO A JOB SITE WHERE A NEW BUILT-UP ROOF IS BEING INSTALLED. THE PURPOSE IS TO AFFORD "HANDS ON" EXPERIENCE INSPECTING THE APPLICATION PROCESS, AND OFFER OPPORTUNITY TO DISCUSS SPECIFIC PROBLEMS WITH THE WORKMEN.

SECOND DAY

1:00 - 2:50 LESSON 1	FIELD EXERCISE ON MAINTENANCE INSPECTION VISIT ROOF THAT IS AT LEAST 6 MONTHS OLD
	A) POINT OUT AREAS MOST LIKELY TO CAUSE TROUBLE
	B) EXAMINE ROOF, COMPARE WITH NEW ROOF SEEN THIS MORNING
2:50 - 3:10	B R E A K
3:10 - 5:00 LESSON 2	CLASSROOM LESSON ON MAINTENANCE REVIEW OF MAINTENANCE INSPECTION
	A) REVIEW: ROOF HISTORICAL FILE
	B) STUDY COMPONENTS OF BUR
	C) SAFETY
	D) FLASHINGS

THIRD DAY

8:00 - 9:50 LESSON 3	ESTABLISHING & MAINTAINING A MAINTENANCE PROGRAM THE IMPORTANCE OF MAINTENANCE
	A) MAINTENANCE & LIFE CYCLE COSTING
	B) MAINTENANCE & LONGEVITY
	C) TROUBLE SHOOTING
9:50 - 10:10	B R E A K
10:10 - 12:00 LESSON 4	MAINTENANCE PROGRAM MAINTENANCE & REPAIR - MEMBRANE
	A) TYPES OF DEFECTS
	B) CAUSE & EFFECT
	C) REPAIR PROCEDURE
12:00 - 1:00	L U N C H

1:00 - 2:50 MAINTENANCE PROGRAM
LESSON 5 MAINTENANCE & REPAIR - FLASHINGS & DRAINAGE

A) TYPES OF DEFECTS

B) CAUSE OF EFFECT

C) REPAIR PROCEDURE

2:50 - 3:10 B R E A K

3:10 - 5:00 MAINTENANCE PROGRAM
LESSON 6 MAINTENANCE VS. REPLACEMENT & REVIEW

A) COST CONSIDERATIONS

B) EXPECTED LONGEVITY

C) DECISION MAKING

LESSON 1

ROOF MAINTENANCE

1:00 to 2:50

ESTABLISHING AND CONDUCTING A ROOF MAINTENANCE PROGRAM INCLUDING INSPECTIONS

LESSON PLAN 1

1. SUBJECT: ROOF MAINTENANCE

2. OBJECTIVES: TO PROVIDE GUIDELINES FOR ESTABLISHING AND CONDUCTING A ROOF MAINTENANCE PROGRAM.

3. LESSON OUTLINE:

	SUBJECT	TIME REQUIRED
A.	INTRODUCTION	5 MINUTES
B.	HISTORICAL FILE	5 MINUTES
C.	INSPECTIONS	10 MINUTES
D.	SEMIANNUAL ROOF INSPECTION FORM	15 MINUTES
E.	INSPECTION EQUIPMENT	5 MINUTES
F.	SAFETY	15 MINUTES
G.	ROOF SYSTEMS COMPONENTS	5 MINUTES
H.	GRAVEL STOPS	10 MINUTES
I.	BASE & COUNTERFLASHING	10 MINUTES
J.	COPING	5 MINUTES
K.	VENT FLASHING	5 MINUTES
L.	PITCH PANS	5 MINUTES
M.	THRU-WALL FLASHING	10 MINUTES
N.	EXPANSION JOINTS	10 MINUTES
	TOTAL	115 MINUTES

4. STUDENT ASSIGNMENTS:
REVIEW FLASHING DETAILS IN "ROOF MAINTENANCE MANUAL"

5. TRAINING AIDES & HANDOUTS:
A) 1 35mm SLIDE PROJECTOR
B) SCREEN
C) HEAT GUN & MOISTURE METER
D) OVERHEAD PROJECTOR

6. LECTURE:

A) INTRODUCTION (5 MINUTES): STATE THE LESSON PURPOSE.

B) HISTORICAL FILE (5 MINUTES):

DISCUSS:

1) ROOF PLANS AND SPECIFICATIONS
2) CONTRACT DOCUMENTS
3) NAME AND ADDRESS OF ARCHITECT, CONSULTANT, CONTRACTOR, AND OTHER PERSONS OF FIRMS CONCERNED WITH ROOF INSTALLATION
4) ALL CORRESPONDENCE OR NOTES BETWEEN PARTIES INVOLVED WITH ROOF INSTALLATION
5) BONDS OR GUARANTEES FOR MATERIAL MANUFACTURER AND/OR 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

C) INSPECTIONS: (10 minutes)

DISCUSS:

THE KEY TO PROPER ROOF MAINTENANCE BEING THE ADOPTION OF A PERIODIC INSPECTION SYSTEM AND WHEN THESE INSPECTIONS SHOULD BE MADE.

THE IMPORTANCE OF CHECKING THE ROOFING SYSTEM DURING INSPECTION.

D) INSPECTION ROOF FORMS: (15 minutes)

DISCUSS:

THE WAY TO USE AND COMPLETE THEM

E) INSPECTION EQUIPMENT: (5 minutes)

THE FOLLOWING TOOLS AND EQUIPMENT ARE REQUIRED 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, COAL CHISEL
9. WHISK BROOM AND WIRE BRUSH
10. ROPE AND GLOVES (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

F) SAFETY: (15 minutes)

STRESS:

A) EXTREME CAUTION MUST BE EXERCISED WHEN WORKING ON ROOFS, AND INSPECTORS SHOULD INSIST UPON GOOD SAFETY PROCEDURES.

B) LADDERS SHOULD BE STURDY, FIRMLY SET AT BASE, AND SECURELY TIED OFF AT THE TOP.

C) MATERIALS AND EQUIPMENT SHOULD BE HOISTED UP - NOT CARRIED UP THE LADDERS.

D) CHECK KETTLES AND HOISTED OR PUMPING EQUIPMENT SHOULD BE CHECKED REGULARLY WITH THE MANUFACTURERS INSTRUCTIONS.

E) HAND TOOLS MUST BE USED AND STORED PROPERLY.

F) AFTER SEVERE STORMS, USE EXTREME CAUTION AROUND ELECTRICAL LINES. NEVER STEP BACKWARDS WITHOUT LOOKING FIRST.

G) ROOF SYSTEMS COMPONENTS: (55 minutes)

1. MEMBRANE
2. FLASHINGS
   A) GRAVEL STOPS
   B) BASE FLASHINGS
   C) COUNTER FLASHING
   D) COPING
   E) VENT FLASHINGS
   F) PITCH PANS
   G) THRU-WALL FLASHINGS
   H) EXPANSION JOINT

ROOF MAINTENANCE

INTRODUCTION (5 minutes)

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 COURSE 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 (5 minutes)

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 (10 minutes)

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 CHECK-LIST 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.

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.

SEMIANNUAL ROOF INSPECTION REPORT FORM
(15 minutes)

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:
   _____
   _____

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: (USE BACK OF PAGE IF NECESSARY)
   _____
   _____

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. DOWNSPOTS:
   OPEN AND IN GOOD CONDITION _____
   SECURELY FASTENED _____
   BENT OR DAMAGED METAL _____
   SPLASH BLOCKS IN PLACE _____

5. RECOMMENDED TREATMENT FOR DRAINAGE SYSTEM:
   (USE BACK OF PAGE IF NECESSARY)
   _____
   _____

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

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:
   _____
   _____

5. REMARKS: (ADD ADDITIONAL SHEETS AS REQUIRED)

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. THESE SHOULD ONLY BE INSTALLED ON A ROOF UNDER THE SUPERVISION OF A MAINTENANCE PERSON.

PHOTOGRAPHS ARE VALUABLE 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 (5 minutes)

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 (¼" 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 (15 minutes)

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 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 (5 minutes)

THE BASIC COMPONENTS OF A BUILT-UP ROOF SYSTEM (BURS) ARE: (1) THE MEMBRANE, (2) FLASHINGS, AND 93) 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 ULTRA-VIOLET 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 (LIGHTER FLUID, KEROSENE 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 TWO BASIC TYPES OF FELT: ORGANIC 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.

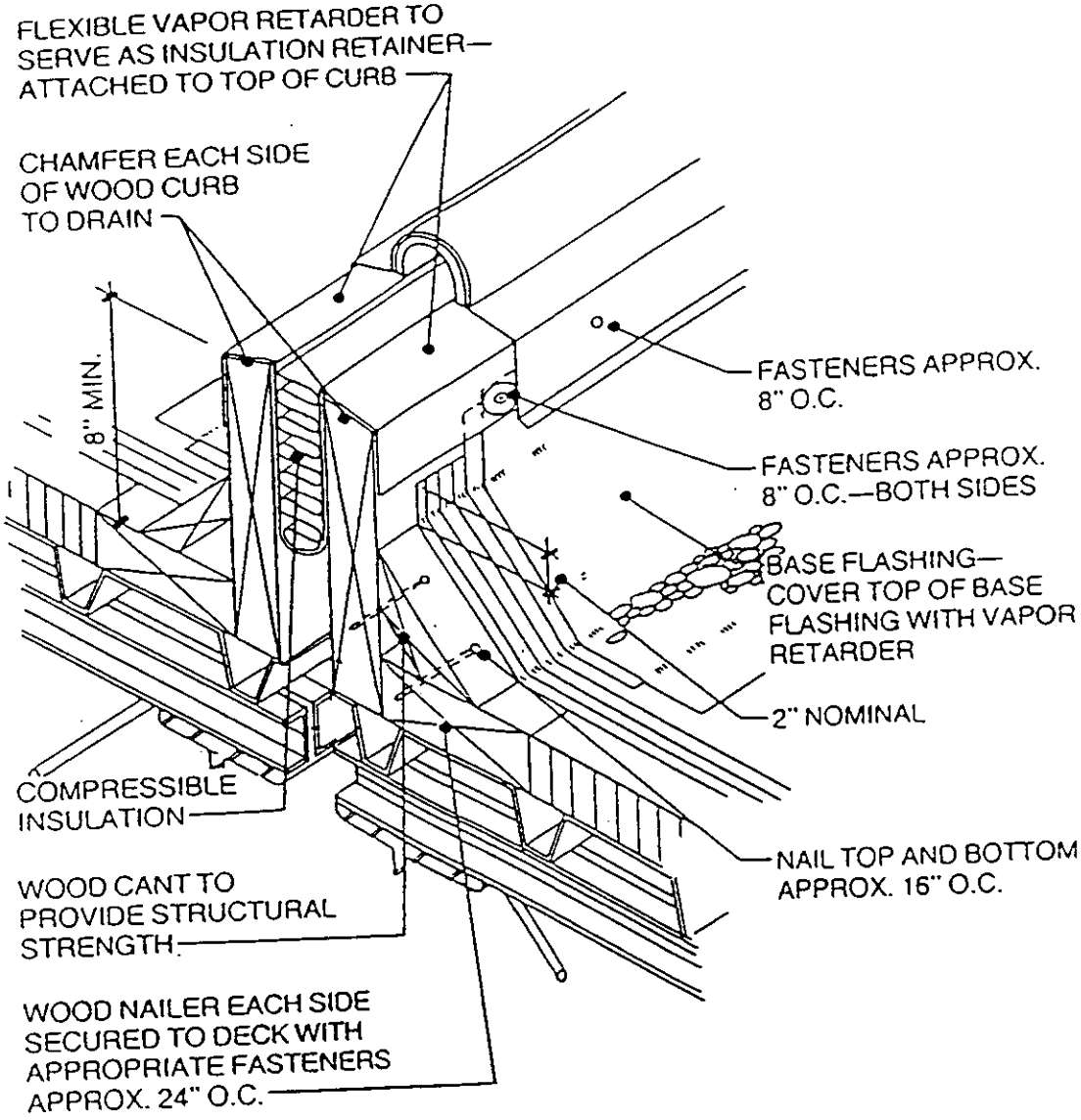
(C) GLASS FELTS ARE MADE OF VERY FINE STRANDS OF GLASS FIBERS.

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 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 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. (35 minutes)

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 BROKEN CONTINUATION OF THE FLASHING 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.


FLEXIBLE VAPOR RETARDER TO SERVE AS INSULATION RETAINER— ATTACHED TO TOP OF CURB
CHAMFER EACH SIDE OF WOOD CURB TO DRAIN
8" MIN.
FASTENERS APPROX. 8" O.C.
FASTENERS APPROX. 8" O.C.—BOTH SIDES
BASE FLASHING— COVER TOP OF BASE FLASHING WITH VAPOR RETARDER
2" NOMINAL
COMPRESSIBLE INSULATION
NAIL TOP AND BOTTOM APPROX. 16" O.C.
WOOD CANT TO PROVIDE STRUCTURAL STRENGTH
WOOD NAILER EACH SIDE SECURED TO DECK WITH APPROPRIATE FASTENERS APPROX. 24" O.C.

1980

C-2

(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).

lesson 2

ROOF MAINTENANCE

3:10 - 5:00

field trip, maintenance and inspection

LESSON PLAN 2

1. SUBJECT: ROOF MAINTENANCE

2. OBJECTIVES: TO WALK THROUGH THE ACTUAL PROCEDURE OF A ROOF INSPECTION AS REQUIRED FOR MAINTENANCE.

3. LESSON OUTLINE:

	SUBJECT		TIME REQUIRED
A.	INTRODUCTION		10 MINUTES
B.	SAFETY REVIEW		10 MINUTES
C.	INSPECTION EQUIPMENT		5 MINUTES
D.	EVERYONE ON THE ROOF		5 MINUTES
E.	THE ROOF INSPECTION:		80 MINUTES
	TO INCLUDE:	GRAVEL STOPS	
		DRAINS	
		BASE FLASHINGS	
		COUNTERFLASHINGS	
		COPING	
		PITCH PLANS	
		EXPANSION JOINTS	
		THRU-WALL FLASHINGS	
		BLISTERS	
		SPLITS	
		BARE FELT	
		WEATHER DAMAGE	
		TOTAL	110 MINUTES

4. TRAINING AIDS & EQUIPMENT

ROOF INSPECTION EQUIPMENT

1. CLIP BOARD, PAPER, REPORT FORMS, 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 COLD CHISEL
9. WHISK BROOM AND WIRE BRUSH
10. ROPE AND GLOVES (¼" NYLON ROPE, LEATHER GLOVES)
11. PAINT SPRAY CAN
12. DRY RAGS, MINERAL SPIRITS (FOR CLEAN UP)
13. MOISTURE METER, DIRECT READING
14. HEAT GUN (NON-CONTACT INFRA-RED THERMOMETER)
15. POLAROID CAMERA WITH FILM

5. MAINTENANCE ROOF INSPECTION

(A) INTRODUCTION (10 MINUTES) STATE THE LESSON PURPOSE

(B) SAFETY REVIEW (10 MINUTES)

DISCUSS:

1. PROPER SAFETY PROCEDURES, SUCH AS USE OF LADDERS, AVOIDANCE OF SHARP EDGES OF THE FLASHINGS, DON'T BACK UP WITHOUT LOOKING.
2. OSHA RULES RELATIVE TO WORK IN HIGH PLACES.
3. MAKE SURE CLASS IS DRESSED PROPERLY IN SHOES WITH NON-SLIP SOLES, LONG SLEEVES AND LEATHER GLOVES.

(C) INSPECTION EQUIPMENT (5 MINUTES)

AT THIS TIME A COMPLETE INVENTORY SHOULD BE MADE OF THE INSPECTION EQUIPMENT THAT WILL BE USED (SEE 4 ABOVE)

(D) EVERYONE ON THE ROOF (5 MINUTES)

THE INSTRUCTOR LEADS THE GROUP ONTO THE ROOF, EXPLAINING AS HE GOES THE PROPER WAY TO CLIMB A LADDER. HANDS ON SIDE RAILS AND FEET ONLY ON THE RUNGS.

(E) THE ROOF INSPECTION (80 MINUTES)

AFTER A BRIEF REVIEW OF THE VARIOUS PARTS OF THE ROOF (SEE ITEM 3 ABOVE), THE INSTRUCTOR WILL LEAD THE CLASS THROUGH THE EXAMINATION OF THE VARIOUS PARTS OF THE ROOF SYSTEM, AS DESCRIBED IN THE LESSON OUTLINE.

(F) EVERYONE SAFELY OFF THE ROOF

ONCE ON THE ROOF IT IS UP TO THE INSTRUCTOR TO EXPLAIN TO THE CLASS WHAT THEY ARE LOOKING FOR IN SUCH A WAY THAT THEY CAN SEARCH FOR ANY PROBLEMS IN AN ORDERLY WAY. THIS EXPLANATION WILL FOLLOW THE LESSON OUTLINE AS SET FORTH IN PART 3.

GRAVEL STOPS; THESE ARE MADE OF A MATERIAL DIFFERENT FROM THE ROOF MEMBRANE AND FREQUENTLY EXPAND AND CONTRACT AT A DIFFERENT RATE. CHECK CAREFULLY TO SEE IF THIS DIFFERENTIAL MOVEMENT HAS CAUSED ANY OPENINGS.

DRAINS; FREQUENTLY GET TOTALLY OR PARTIALLY STOPPED UP AND MUST BE CLEANED AT EVERY INSPECTION. IF NO DEBRIS IS SEEN, LOOK FOR SIGNS OF STANDING WATER AROUND DRAINS. THIS MIGHT INDICATE AN INTERNAL BLOCKAGE.

BASE FLASHINGS ARE AN IMPORTANT SOURCE OF LEAKS. A VERY HIGH PERCENTAGE OF ALL LEAKS ORIGINATE AT THE EDGES OF THE ROOF, AND ALL FLASHINGS NEED TO BE CHECKED VERY CAREFULLY AT EVERY INSPECTION.

COUNTERFLASHINGS; EVERYTHING SAID ABOUT BASE FLASHINGS APPLIES HERE PLUS THE FACT THAT THEY ARE MORE EASILY DAMAGED.

COPING; JOINTS ARE ONE OF THE PRIME CAUSES OF LEAKS.

PITCH PANS; TEND TO DRAIN OUT OR ARE FILLED WITH THE IMPROPER MATERIAL AND WHEN THEY DO THEY DEVELOP CRACKS THAT CAN LEAD TO LEAKS. LOOK AT THE DETAILS IN THE BACK OF THIS BOOK TO FIND MANY BETTER WAYS TO FLASH AREAS WHERE PITCH PANS ARE USED.

EXPANSION JOINTS; BY THEIR VERY NAME YOU CAN TELL THAT THEY ARE LOCATED IN AREAS OF MOVEMENT. BECAUSE OF THIS THEY MUST BE CHECKED VERY CLOSELY FOR DAMAGE FROM MOVEMENT.

THRU-WALL FLASHINGS ARE IMPOSSIBLE TO INSPECT THOROUGHLY BECAUSE MOST OF THEM ARE IN THE WALL, BUT THE PART THAT IS EXPOSED MUST BE CHECKED VERY CAREFULLY.

5e THE ROOF INSPECTION

BLISTERS; DO NOT LEAK, BUT THEY CAN BECOME THE CAUSE OF LEAKS IF THEY ARE RUPTURED. ALL BLISTERS ON THE ROOF MUST BE LOCATED AND CHECKED EVERY INSPECTION. MAKE IT A POINT NOT TO STEP ON BLISTERS BUT IF THEY BECOME TOO LARGE (SAY TWO SQUARE FEET) IT MAY BECOME NECESSARY TO REPAIR THEM.

SPLITS; ARE FREQUENTLY CAUSED BY EXTREME WEATHER, BY INSTALLATION PROBLEMS OR BECAUSE OF AGE. IN ANY CASE, THEY MUST BE LOCATED AND REPAIRED BEFORE THEY WET LARGE AREAS OF INSULATION.

BARE FELT; WILL LEAD TO FURTHER DEGRADATION OF THE MEMBRANE AND MUST BE COVERED AS SOON AS IT IS DISCOVERED.

WEATHER DAMAGE; INCLUDES NEARLY ANYTHING THAT HAPPENS TO THE ROOF AS A RESULT OF BAD WEATHER. THIS DAMAGE CAN INCLUDE SUCH THINGS AS FALLEN TREE LIMBS, WIND UPLIFT, LIGHTNING DAMAGE, STONE SCOURS AND OTHERS.

LESSON 3

ROOF MAINTENANCE

8:00 - 9:50

TROUBLE SHOOTING AND ROOF REPAIR

LESSON 3

1. SUBJECT: ROOF MAINTENANCE

2. OBJECTIVES: TO DISCUSS TROUBLE SHOOTING AND REPAIRS

3. LESSON OUTLINE: (110 MINUTES)

SUBJECT		TIME REQUIRED
A.	INTRODUCTION	10 MINUTES
B.	IMPORTANCE OF TROUBLE SHOOTING	10 MINUTES
C.	MAINTENANCE & LIFE CYCLE COSTING	10 MINUTES
D.	MAINTENANCE & LONGEVITY	20 MINUTES
E.	MINOR REPAIRS	5 MINUTES
F.	MAJOR REPAIRS	10 MINUTES
G.	EMERGENCY REPAIRS	30 MINUTES
H.	SUMMARY	15 MINUTES
	TOTAL	110 MINUTES

4. TRAINING AIDS
   - A) 35mm SLIDE PROJECTOR
   - B) OVERHEAD PROJECTOR
   - C) SCREEN

ESTABLISHING & MAINTAINING A MAINTENANCE PROGRAM

A) INTRODUCTION (10 MINUTES): STATE THE LESSON PURPOSE AND BRIEFLY REVIEW LAST LESSON.

B) IMPORTANCE OF MAINTENANCE ¢ TROUBLE SHOOTING (10 MINUTES): STATE LESSON PURPOSE - DESCRIBE TROUBLE SHOOTING AND SHOW EXAMPLES OF TROUBLE SHOOTING.

C) MAINTENANCE & LIFE CYCLE COSTING (10 MINUTES): SHOW THE IMPORTANCE OF REGULAR MAINTENANCE TO THE LIFE OF THE ROOF. ALSO SHOW HOW SMALL AMOUNTS SPENT ON MAINTENANCE RETURN HUGE DIVIDENDS.

D) MAINTENANCE & LONGEVITY (20 MINUTES): SHOW AND REVIEW THE MANY WAYS A ROOF'S LIFE CAN BE CUT SHORT BY POOR OR NO MAINTENANCE.

E) MINOR REPAIRS (5 MINUTES): THESE ARE ESSENTIALLY "COLD PROCESS" REPAIRS THAT CAN BE DONE BY THE OWNER AFTER THE WARRANTY EXPIRES — DURING WARRANTY TIME, THE CONTRACTOR DOES ALL REPAIRS.

F) MAJOR REPAIRS (10 MINUTES): "HOT PROCESS" REPAIRS REQUIRED AT ANY TIME DURING LIFE OF ROOF AND DONE BY PROFESSIONAL ROOFER PREFERABLY INSTALLER.

G) EMERGENCY REPAIRS (30 MINUTES): REPAIRS DONE (FREQUENTLY UNDER ADVERSE CONDITIONS) TO PREVENT WATER DAMAGE TO THE BUILDING. EXPLAIN THE DETAIL, DEMONSTRATE.

H) SUMMARY (15 MINUTES): SUMMARIZE ABOVE WITH EMPHASIS ON TYPES OF REPAIRS, THEIR EFFECT ON THE LIFE AND THE COST OF THE ROOF.

ESTABLISHING & MAINTAINING A MAINTENANCE PROGRAM

THE IMPORTANCE OF MAINTENANCE (10 MINUTES)

THE MAINTENANCE PROGRAM FOR THE ROOF OF A BUILDING SHOULD BEGIN AT THE TIME THE BUILDING IS BEING BUILT. THE ROOF SHOULD BE DESIGNED SO THAT THE LEAST POSSIBLE AMOUNT OF MAINTENANCE IS REQUIRED. THIS PHILOSOPHY SHOULD START WITH THE DESIGN OF THE ROOF DECK AND CARRY THROUGH WITH THE SELECTION OF THE MEMBRANE PROTECTION THAT IS THE TOP OF THE COMPLETED ROOF. BETWEEN THESE STEPS ALL PARTS OF THE ROOF SHOULD BE DESIGNED IN SUCH A WAY THAT MINIMUM MAINTENANCE IS REQUIRED. THIS PHILOSOPHY SHOULD INCLUDE THE AVOIDANCE OF ROOF MOUNTED EQUIPMENT.

THE COST OF BUILDING THE ROOF AT THE TIME THE BUILDING IS BUILT USUALLY AMOUNTS TO APPROXIMATELY 3 TO 5 PERCENT OF THE COST OF THE BUILDING. THE COST OF REPLACING THAT ROOF SOMETIME IN THE FUTURE CAN AMOUNT TO AS MUCH AS 15 TO 20 PERCENT OF THE COST OF THE BUILDING. FOR THIS REASON ALONE MAINTENANCE IS A VERY IMPORTANT PART OF GETTING THE MOST FOR YOUR MONEY. THERE ARE OTHER REASONS. BETWEEN 60 AND 80 PERCENT OF ALL LAWSUITS RELATED TO BUILDINGS HAVE TO DO WITH THE ROOF AND THE SERVICE IT GIVES.

A. MAINTENANCE & LIFE CYCLE COST (10 MINUTES)

ALONG WITH GOOD DESIGN, MAINTENANCE HAS MORE TO DO WITH EXTENDING LIFE CYCLE COST OF A ROOF THAN NEARLY ANYTHING. IN FACT, WITHOUT GOOD MAINTENANCE, THERE IS NO WAY THAT LIFE CYCLE COST CAN BE KEPT DOWN. THIS INCLUDES THE SEMI-ANNUAL INSPECTIONS AND THE SPECIAL INSPECTIONS REQUIRED AFTER EACH STRESSFUL WEATHER SITUATION.

IN ORDER TO KEEP UP WITH LIFE CYCLE COSTS IT IS NECESSARY TO KEEP GOOD RECORDS OF WHAT IS DONE ON THE ROOF AND HOW MUCH IT COST. THIS STARTS WITH THE ROOF INSTALLATION. NORMALLY, TO GET THE MOST OUT OF THE ROOF IT IS NECESSARY TO INSTALL A FAIRLY GOOD (EXPENSIVE) ROOF IN THE BEGINNING. THIS IS NOT TO SAY THAT JUST BECAUSE A ROOF IS EXPENSIVE, IT IS NECESSARILY GOOD. THERE HAVE BEEN TOO MANY CASES LATELY OF SPECIAL ROOFS THAT COST A GREAT DEAL OF MONEY, BUT GIVE VERY LIMITED SERVICE.

LIFE CYCLE COST REFERS TO THE TOTAL COST OF THE ROOF OVER ITS ENTIRE LIFE. A VERY INEXPENSIVE INSTALLATION THAT REQUIRES A TREMENDOUS AMOUNT OF REPAIR DURING IT'S RATHER SHORT LIFE AND THEN REQUIRES AN EXPENSIVE REPLACEMENT IS NOT GOING TO BE THE MOST ECONOMICAL ROOF IN THE LONG RUN. USUALLY IT IS MUCH MORE ECONOMICAL TO INSTALL A MORE EXPENSIVE ROOF THAT WILL LAST A LONG TIME WITH A MINIMUM OF REPAIR OVER ITS MUCH LONGER LIFE.

B. MAINTENANCE & LONGEVITY (20 MINUTES)

AS MENTIONED BEFORE, MAINTENANCE IS WHAT MAKES LONGEVITY POSSIBLE. NO MATTER HOW GOOD THE ROOF IS, IF IT IS NOT MAINTAINED, SMALL PROBLEMS WILL GROW INTO LARGE PROBLEMS, AND THE ROOF WILL FAIL. FAIL IN THIS CASE MEANS "FAIL TO DO THE JOB FOR WHICH IT WAS DESIGNED", NOT STRUCTURAL FAILURE, ALTHOUGH THERE HAVE BEEN CASES OF THAT BROUGHT ON BY THE LACK OF PROPER MAINTENANCE.

A SMALL CRACK IN THE ROOF MEMBRANE WILL, IF LEFT UNTENDED, WET AN EVER ENLARGING AREA OF INSULATION. (AT THIS POINT INSERT OVEREADS OF RIEI ARTICLE ON "CAN WET INSULATION BE DRIED IN PLACE" FOR DISCUSSION) WET INSULATION IS OF VERY LITTLE INSULATING VALUE AND CAN BE A DEFINITE PROBLEM FOR THE OWNER OF THE BUILDING. FIRST, AND PROBABLY LEAST IMPORTANT, THE BUILDING COSTS MORE TO HEAT OR COOL. MORE IMPORTANT IS THE POSSIBILITY OF WATER DAMAGING THE BUILDING CONTENTS OR EVEN THE BUILDING ITSELF. A RUSTY ROOF DECK CAN LEAD TO RUSTY BAR JOISTS AND EVEN TO STRUCTURAL FAILURE OF THE ENTIRE ROOF SYSTEM.

THE MAINTENANCE INSPECTION THAT DISCOVERS THE "MINOR" PROBLEMS WITH THE ROOF BEFORE THEY CAN BECOME MAJOR IS THE KEY TO LONG LASTING ROOFS. THIS INSPECTION SHOULD BE HELD ON A REGULAR SCHEDULE OF ONCE EVERY SIX MONTHS AT A MINIMUM. THIS SHOULD BE SUPPLEMENTED BY SPECIAL INSPECTIONS AFTER ANY UNUSUAL WEATHER. THE PURPOSE OF THESE INSPECTIONS IS NOT ONLY TO DISCOVER PROBLEMS, BUT TO REPAIR SOME OF THE SMALLER ONES RIGHT ON THE SPOT. THIS LEADS US TO TROUBLE SHOOTING.

C. TROUBLE SHOOTING

TROUBLE SHOOTING DEALS PRIMARILY WITH REPAIR PROCEDURES. THESE FALL INTO THREE BASIC TYPES: MINOR, MAJOR AND EMERGENCY.

1. MINOR REPAIRS. (5 MINUTES)

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. (10 MINUTES)

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. (30 MINUTES)

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 COIL 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.
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, OR ANOTHER COMPETENT ROOFING CONTRACTOR.

BREAK

20 MINUTES

LESSON 4

ROOF MAINTENANCE

10:10 - 12:00

MAINTENANCE AND ROOF REPAIR

LESSON PLAN 4

1. SUBJECT: ROOF MAINTENANCE

2. OBJECTIVES: TO PROVIDE GUIDELINES FOR MAINTENANCE AND REPAIR OF THE BUILT-UP ROOF MEMBRANE

3. LESSON OUTLINE:

SUBJECT		TIME REQUIRED
A)	INTRODUCTION	10 MINUTES
B)	INSPECTION TIMING	5 MINUTES
C)	LONGEVITY	5 MINUTES
D)	REPAIR OF BARE SPOTS	10 MINUTES
E)	REPAIR OF ALLIGATORING	10 MINUTES
F)	REPAIR OF BLISTERS	15 MINUTES
G)	REPAIR OF SPLICES & TEARS	10 MINUTES
H)	REPAIR OF RIDGES, WRINKLING, AND BUCKLING	10 MINUTES
I)	REPAIR OF FISHMOUTHS AND CURLING EDGES	10 MINUTES
J)	REPAIR OF DETERIORATED FELT OR BITUMEN	10 MINUTES
K)	SUMMARY	15 MINUTES
	TOTAL	110 MINUTES

4. TRAINING AIDS

   A) 35mm SLIDE PROJECTOR

   B) OVERHEAD PROJECTOR

   C) SCREEN

5. ROOF MAINTENANCE - MEMBRANES

   A) INTRODUCTION (10 MINUTES): THIS LESSON DEALS ENTIRELY WITH THE ROOF DECK REVIEW ITEMS RELATIVE TO THE DECK FROM THE LAST LESSON.

B) (5 MINUTES): A BRIEF REFRESHER ON THE TIMING OF INSPECTIONS, WHY AND THE DANGER TO THE ENTIRE BUILDING FROM FAILURE TO MAINTAIN A REGULAR SCHEDULE OF INSPECTIONS.

C) (5 MINUTES): A FEW WORDS ON THE SUBJECT OF LONGEVITY OF THE ROOF SYSTEM AND THE EFFECT THE FOLLOWING REPAIRS CAN AHVE ON IT.

D) REPAIR OF BARE SPOTS (10 MINUTES): COVERS THE TECHNIQUES OF THIS TYPE OF REPAIR, THE NEED FOR IT AND SOME OF THE TOOLS AND MATERIALS REQUIRED.

E) REPAIR OF ALLIGATORING (10 MINUTES): DISCUSSES WAYS TO AVOID THE PROBLEM, BEFORE AND AFTER CORRECTING IT. POINT OUT TIME WHEN THIS BECOMES A SERIOUS THREAT TO THE MEMBRANE.

F) BLISERS (15 MINUTES): SHOULD NOT BE ALLOWED TO GET LARGER THAN TWO SQUARE FEET. EXPLAIN THE VARIOUS METHODS OF CORRECTING BLISTERS AND HOW TO TREAT THEM UNTIL THEY ARE CORRECTED.

G) REPAIR OF SPLITS AND TEARS (10 MINUTES): WHEN AND HOW TO REPAIR THESE DEFECTS.

H) REPAIR OF RIDGES, WRINKLING & BUCKLING (10 MINUTES): THESE SOMETIMES REQUIRE MODIFICATIONS TO THE INSULATION.

I) REPAIR OF FISHMOUTHS AND CURLING EDGES (10 MINUTES): WHEN AND HOW TO REPAIR THESE DEFECTS.

J) REPAIR OF DETERIORATED FELT OR BITUMEN (10 MINUTES): THESE PROBLEMS MUST BE REVERSED AND THEN CORRECTED. METHODS BY WHICH THIS CAN BE DONE WILL BE DISCUSSED.

K) SUMMARY (15 MINUTES): REVIEW THE VARIOUS METHODS USED TO KEEP THE MEMBRANE IN GOOD CONDITION.

AS POINTED OUT LAST PERIOD, TROUBLE SHOOTING DEALS PRIMARILY WITH REPAIR PROCEDURES. THESE FALL INTO THREE BASIC TYPES: MINOR, MAJOR AND EMERGENCY. EACH OF THESE WAS DESCRIBED LAST PERIOD AND IS IN THE PASSOUT MATERIAL YOU HAVE. LET US HERE LOOK AT THEM AS THEY APPLY TO THE MEMBRANE.

SOME OF THE MEMBRANE DEFECTS THAT MAY SHOW UP ARE:

1. BARE SPOTS. (10 MINUTES)

   A) BARE SPOTS ARE AREAS OF THE MEMBRANE NOT COMPLETELY COVERED BY AGGREGATE. THIS LEAVES THE BITUMEN EXPOSED TO PUNCTURE INJURY AND THE ULTRA VIOLET 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/RESTAURANT, AND EMBED GRAVEL TO COVER AREA. EVEN LOOSE GRAVEL IS BETTER THAN NONE AT ALL.

2. ALLIGATORING -- CRACKING OF BITUMEN. (10MINUTES)

   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. (15 minutes)

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 MOISTURE 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 BLISTER. (NOTE: IT IS EASIER TO REMOVE GRAVEL IN COOLER TEMPERATURE, OR EARLY IN THE MORNING). AFTER GRAVEL IS REMOVED, AND THE SURFACE CLEANED, CUT OUT THE ENTIRE BLISTER TO A POINT WHERE THE FELT IS STILL ADHERED. THEN ALLOW THE AREA TO DRY THOROUGHLY.

WHEN DRY, FILL THE DEPRESSED AREA WITH LAYERS OF FELT (CUT TO FIT) SET IN ROOFING CEMENT. THEN PRIME THE AREA SURROUNDING THE PATCH. WHEN PRIMER IS DRY, APPLY FOUR LAYERS OF FELT IN ROOF CEMENT. THE FIRST LAYER SHOULD EXTEND 2" OUTSIDE THE FIRST, ETC.. WHEN ALL FOUR LAYERS ARE IN PLACE, TROWEL ON MORE MASTIC AND EMBED GRAVEL OVER AREA.

AN ALTERNATE METHOD OF BLISTER REPAIR IS THE "X-CUT" METHOD. AFTER REMOVAL OF GRAVEL (SEE ABOVE) AND CLEANING THE SURFACE, MAKE TWO DIAGONAL CUTS IN THE BLISTER (IN LIEU OF REMOVING ENTIRE BLISTER AREA). THESE CUTS MUST EXTEND TO THE EDGES WHERE FELT IS STILL ADHERED. TURN BACK THE "EARS" FORMED BY THE X-CUTS, AND ALLOW THE INTERIOR OF THE BLISTER TO DRY THOROUGHLY. WHEN COMPLETELY DRY, APPLY ROOFING CEMENT IN THE BLISTER AND LAY THE "EARS" BACK DOWN. SMOOTH OUT THE SURFACE BY PRESSING DOWN UNTIL MASTIC OOZES OUT OF THE "X-CUTS". THEN APPLY FOUR LAYER PATCH AS OUTLINED ABOVE, AND EMBED GRAVEL.

4. SPLITTING AND TEARS IN MEMBRANE. (10 MINUTES)

A) LONG CRACKS, SPLITS OR TEARS IN THE MEMBRANE OFTEN INDICATE SERIOUS PROBLEMS, AND THE CAUSE JUST BE 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 <u>HOT</u> PROCESS METHODS AND TECHNICAL SKILL. IT SOMETIMES 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. (10 MINUTES)

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.

TIME FOR WRINKLING 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. (10 MINUTES)

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.

LESSON FIVE

ROOF MAINTENANCE

1:00 - 2:50

MAINTENANCE AND REPAIR OF ROOF FLASHING & DRAINAGE

LESSON PLAN 5

1. SUBJECT: ROOF MAINTENANCE

2. OBJECTIVES: TO PROVIDE GUIDELINES FOR MAINTENANCE AND REPAIR OF ROOF FLASHINGS

3. LESSON OUTLINE:

	SUBJECT	TIME REQUIRED
A)	INTRODUCTION	10 MINUTES
B)	BASE FLASHINGS	15 MINUTES
C)	COPING & COUNTER-FLASHING	15 MINUTES
D)	VENTS & PITCH PANS	15 MINUTES
E)	GRAVEL STOPS	15 MINUTES
F)	DRAINAGE SYSTEM PROBLEMS	20 MINUTES
G)	SUMMARY	20 MINUTES
	TOTAL	110 MINUTES

4. TRAINING AIDS:

A) 35mm SLIDE PROJECTOR

B) OVERHEAD PROJECTOR

C) SCREEN

5. ROOF MAINTENANCE:

A) INTRODUCTION (15 MINUTES): REVIEW PAST LESSONS RELATIVE TO FLASHINGS AND REVIEW LESSON 4 ABOUT THE MEMBRANE BEFORE GETTING INTO THIS DETAILED STUDY OF FLASHINGS.

B) BASE FLASHINGS (15 MINUTES): THIS FLASHING IS ESSENTIALLY PART OF THE ROOF MEMBRANE AND AS SUCH IS VERY IMPORTANT. COVER THE WAYS THIS FLASHING IS MADE AND PROTECTED.

C) COPING AND COUNTER-FLASHING (15 MINUTES): BOTH OF THESE FLASHINGS ARE AWAY FROM THE MAIN MEMBRANE AND USUALLY OF A DIFFERENT MATERIAL. SPECIAL CARE SHOULD BE EXPLAINED.

6. 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/RESTAURANT MATERIALS. ALL LOOSE GRAVEL SHOULD BE REMOVED BEFORE, AND REPLACED AFTER THE APPLICATION, AND ROOF SURFACES MUST BE DRY.

D) VENTS AND PITCH PANS (15 MINUTES): PLUMBING VENTS ARE USUALLY MADE OF LEAD AND REQUIRE SPECIAL HANDLING. PITCH PANS ARE A VERY OLD AND INCREASINGLY CONTROVERSIAL WAY OF SEALING SMALL PENETRATIONS.

E) GRAVEL STOPS (15 MINUTES): USED TO KEEP GRAVEL ON TOP OF THE BUILDING, THE GRAVEL STOP IS NOW ACCUSED OF CAUSING MORE PROBLEMS THAN THEY SOLVE.

F) DRAINAGE SYSTEM PROBLEMS (20 MINUTES): THESE PROBLEMS RELATED TO GETTING THE WATER OFF THE ROOF INVOLVE ROOF DRAINS, SCUPPERS, AND GUTTERS.

G) SUMMARY (20 MINUTES): SUMMARIZE EVERYTHING RELATED TO THE FLASHINGS THAT SURROUND ALL ROOF PENETRATIONS. BEAR IN MIND THAT 85% OF ALL LEAKS START AT OR NEAR PENETRATIONS.

IT IS DIFFICULT TO EMPHASIZE STRONGLY ENOUGH THE IMPORTANCE OF MAINTENANCE AND REPAIR OF FLASHINGS. ESTIMATES RUN AS HIGH AS 80% OF ALL ROOF LEAKS ORIGINATE AT EDGES AND OPENINGS IN THE ROOF. THESE ARE THE PLACES WHERE FLASHINGS OCCUR. PUT THAT WITH THE FACT THAT FLASHINGS ARE FREQUENTLY MADE OF DISSIMILAR MATERIALS FROM THE ROOF, AND YOU HAVE THE MAKINGS OF A MAJOR PROBLEM. MAINTENANCE OF FLASHINGS IS A MAJOR PROBLEM. LIKE SO MUCH OF MAINTENANCE, IF IT IS CAUGHT AND CORRECTED IN TIME, THE PROBLEM IS MINIMIZED.

THIS PERIOD WE ARE GOING TO STUDY THE PROBLEMS INVOLVED IN THE MAINTENANCE OF FLASHINGS. WE ARE ALSO GOING TO STUDY THE MAINTENANCE OF THE DRAINAGE SYSTEM OF THE ROOF. DRAINAGE SYSTEMS ARE CLOSELY RELATED TO FLASHINGS. FREQUENTLY THE AREA AROUND THE DRAIN IS FLASHED. IN A NUMBER OF THE OLDER ROOFS, THE DRAINAGE SYSTEM MATERIAL IS THE SAME AS THE FLASHING MATERIAL.

FLASHING DEFECTS

1. BASE FLASHING. (15 MINUTES)

   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.

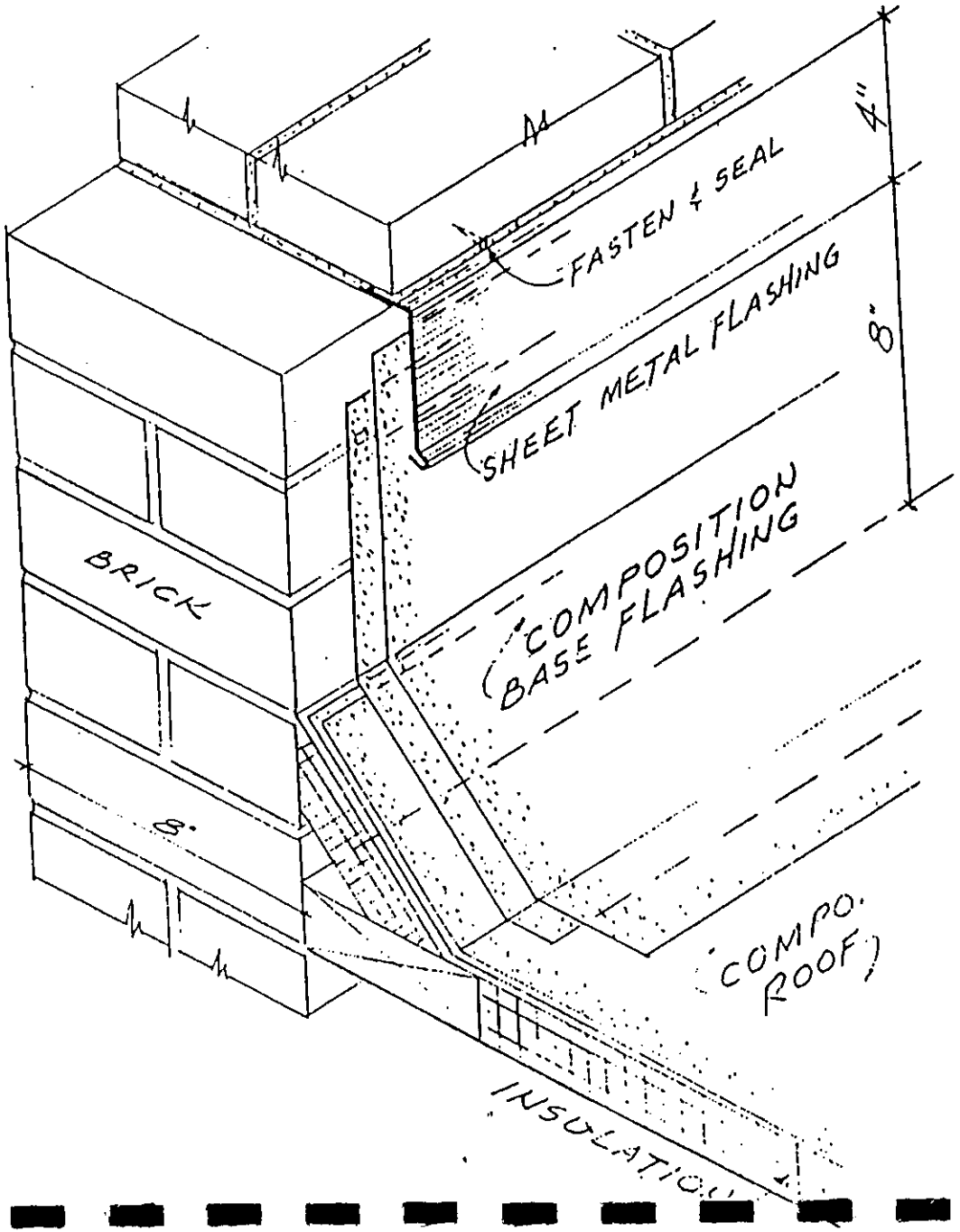
ADHESION DEFECTS CAN USUALLY BE REMEDIED BY APPLYING FLASHING CEMENT TO THE LOOSE AREAS. AGAIN, THIS IS NOT A PERMANENT SEAL, SO EACH INSPECTION REQUIRES CLOSE ATTENTION TO ALL VERTICAL LAPS, AS WELL AS THE BASE CONNECTION TO THE MEMBRANE.

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 REINFORCING 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 (15 MINUTES)

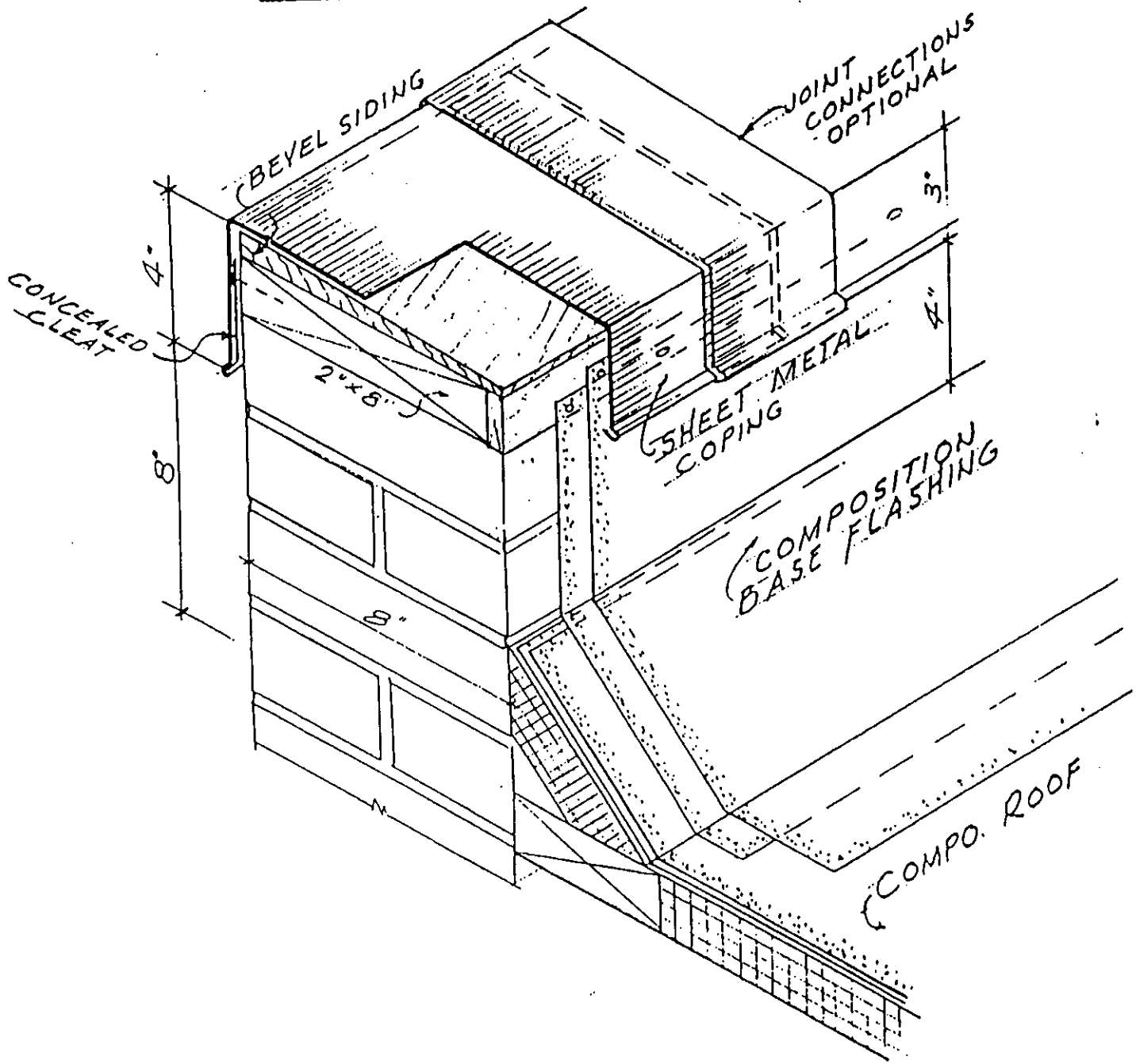
A) THE MAJOR PROBLEMS WITH METAL FLASHING ARE DAMAGE TO THE METALS, SEALS AT LAP SPLICES, LOOSENED FASTENINGS, AND CAULKING WHERE COUNTERFLASHINGS ENTER MASONRY GROOVES.

STANDARD ONE PIECE FLASHING



RM 5-5

SHEET METAL COPING



RM 5-6

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. (15 MINUTES)

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 MEMBRANE.. 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 MEMBRANE, AND FASTEN IT SECURELY. NEXT, BUILD UP PLIES OF FELT AND ROOFING CEMENT OVER THE FLANGES TO THE LEVEL OF THE SURROUND-MEMBRANE. THEN CUT THREE LAYERS OF FELT TO FIT NUGLY 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, 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.

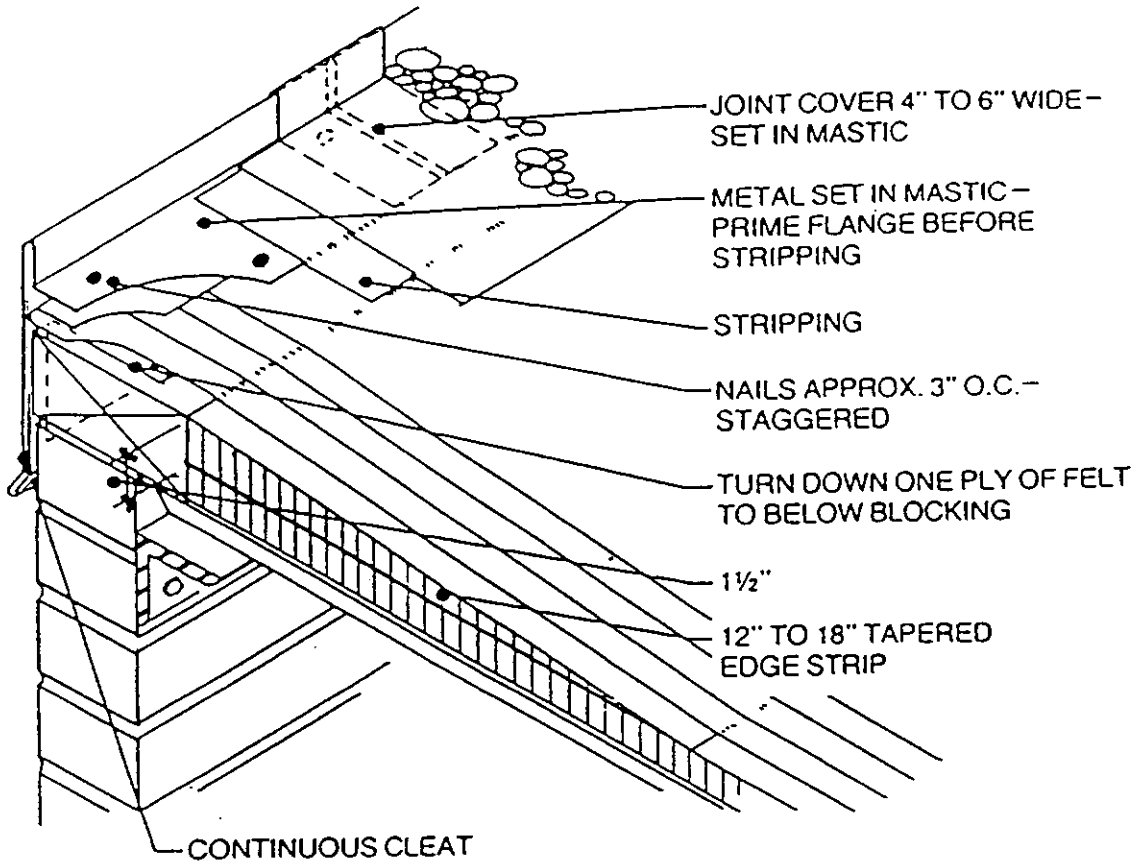
4. GRAVEL STOPS. (15 MINUTES)

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 LEAKS. 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.

LIGHT METAL ROOF EDGE



NOTES:

ENVELOPE SHOWN FOR COAL TAR PITCH AND LOW SLOPE ASPHALT.

ATTACH NAILER TO MASONRY WALL. REFER TO FACTORY MUTUAL DATA SHEET 1-49.

THIS DETAIL SHOULD BE USED ONLY WHERE DECK IS SUPPORTED BY THE OUTSIDE WALL.

THIS DETAIL SHOULD BE USED WITH LIGHT GAUGE METALS, SUCH AS 16 OZ. COPPER, 24 GAUGE GALVANIZED METAL OR 0.040" ALUMINUM. A TAPERED EDGE STRIP IS USED TO RAISE THE GRAVEL STOP. FREQUENT NAILING IS NECESSARY TO CONTROL THERMAL MOVEMENT.

WOOD BLOCKING MAY BE SLOTTED FOR VENTING WHERE REQUIRED.

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DRAINAGE SYSTEM DEFECTS (20 MINUTES)

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 <u>FREQUENTLY</u> CHECKED AND CLEANED.

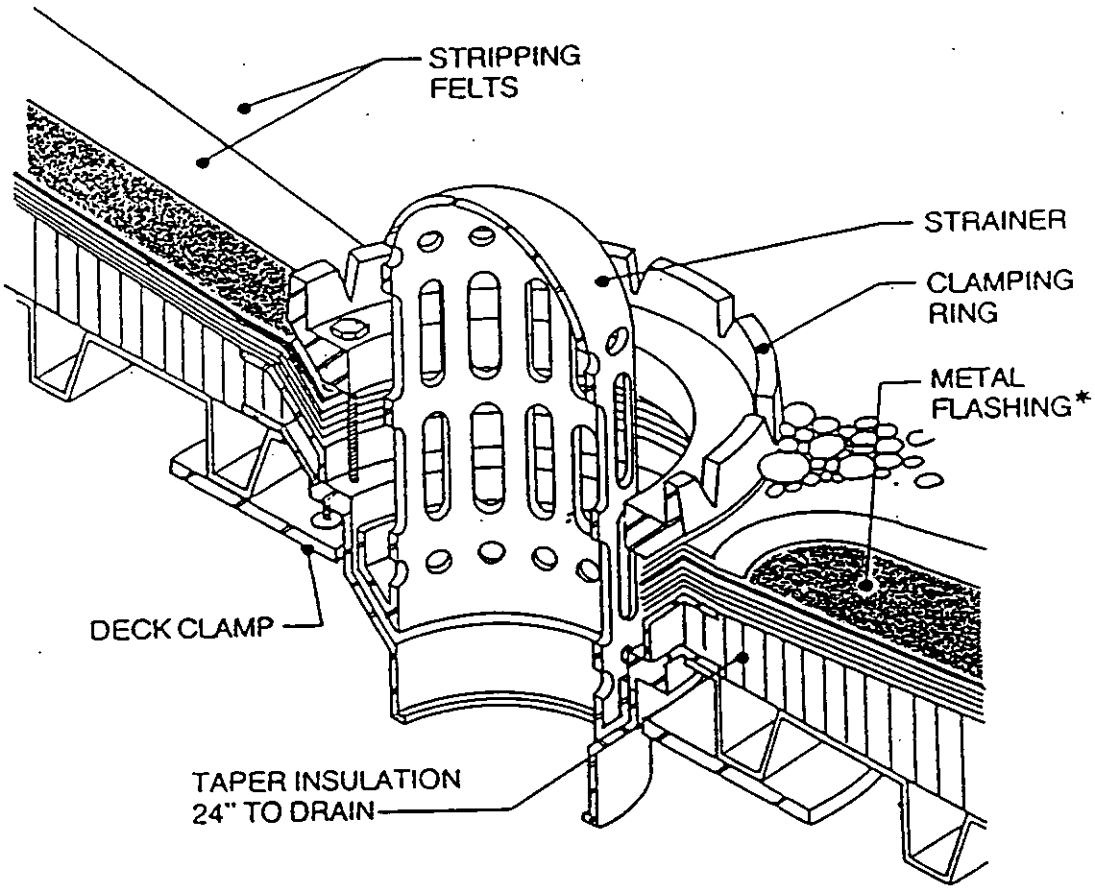
NOTE: IF ROOF DRAINS LEAK, THIS IS A "MAJOR" REPAIR. A COMPETENT ROOFING CONTRACTOR SHOULD PERFORM THIS REPAIR OR REPLACEMENT. IF THE INTERNAL DRAIN PIPE LEAKS, THIS MAY REQUIRE A COMPETENT PLUMBING CONTRACTOR.

2. SCUPPERS

SCUPPERS ARE A VERY POOR WAY TO DRAIN A ROOF. THEY SHOULD BE USED ONLY AS SUPPLEMENTAL DRAINS TO INTERIOR PIPING. THEY ARE, HOWEVER, CHEAP AND BECAUSE OF THIS WILL SEEN ON ROOFS FOR SOME TIME TO COME.

(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.

ROOF DRAIN



NOTES:

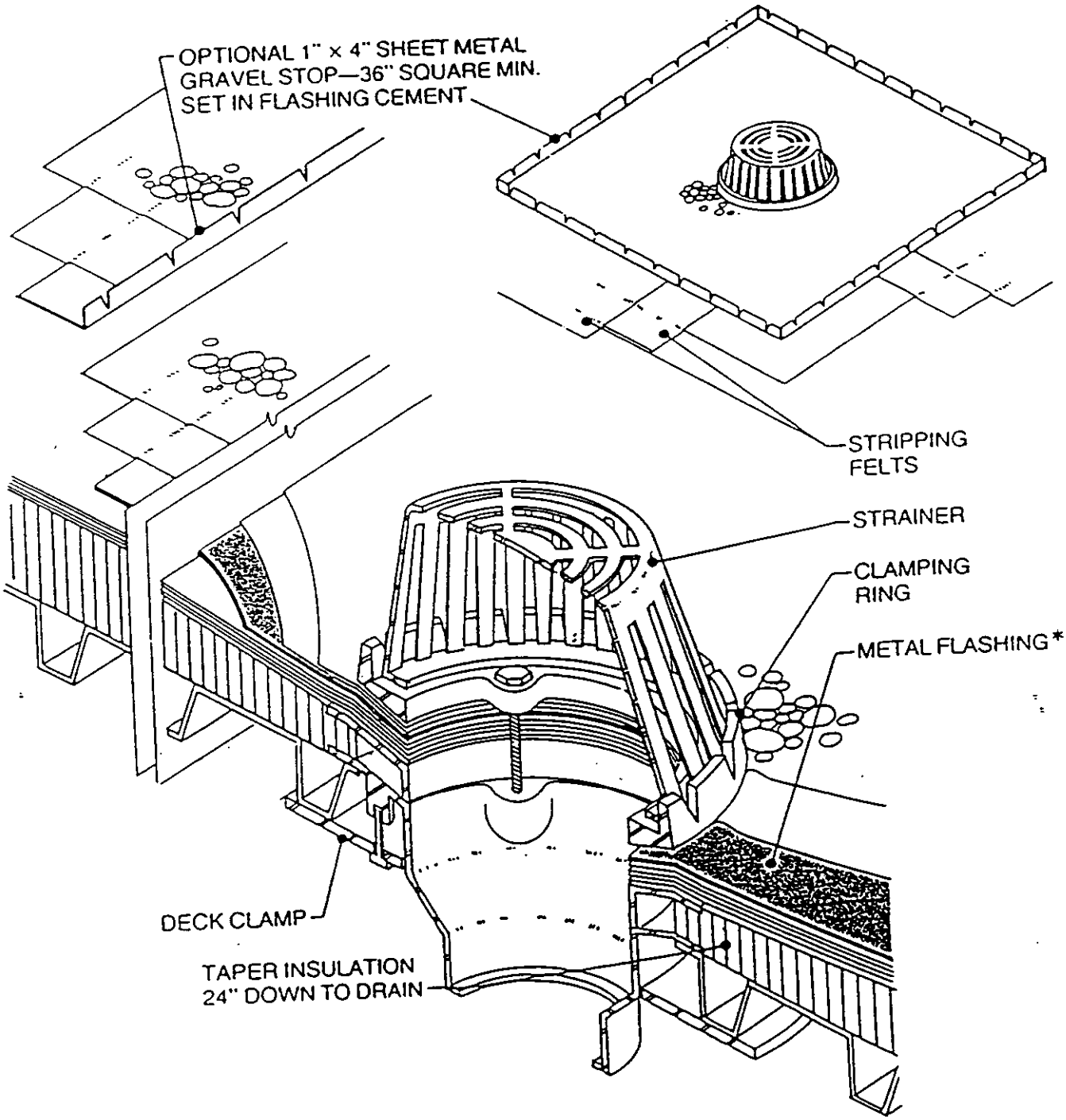
*MIN. 30" SQUARE, 2½ LB. TO 4 LB. LEAD OR 16 OZ. SOFT COPPER FLASHING, SET ON FINISHED ROOFING FELTS IN MASTIC. PRIME TOP SURFACE BEFORE STRIPPING.

MEMBRANE PLIES, METAL FLASHING, AND FLASH-IN PLIES EXTEND UNDER CLAMPING RING.

STRIPPING FELTS EXTEND 4" AND 6" BEYOND EDGE OF FLASHING SHEET.

1980

W-1



NOTES:

*MIN. 30" SQUARE, 2½ LB. TO 4 LB. LEAD OR 16 OZ. SOFT COPPER FLASHING, SET ON FINISHED ROOFING FELTS IN MASTIC. PRIME TOP SURFACE BEFORE STRIPPING.

MEMBRANE PLIES, METAL FLASHING, AND FLASH-IN PLIES EXTEND UNDER CLAMPING RING.

STRIPPING FELTS EXTEND 4" AND 6" BEYOND EDGE OF FLASHING SHEET.

1980

W-2

(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.

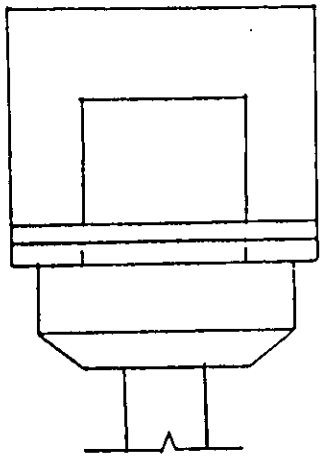
(B) THE CAUSE OF CLOGGING IS THE SAME AS ROOF DRAINS AND SCUPPERS.

THE CAUSE OF LOOSE ANCHORS AND LAP JOINTS IS USUALLY DUE TO EXPANSION AND CONTRACTION OF THE METAL.

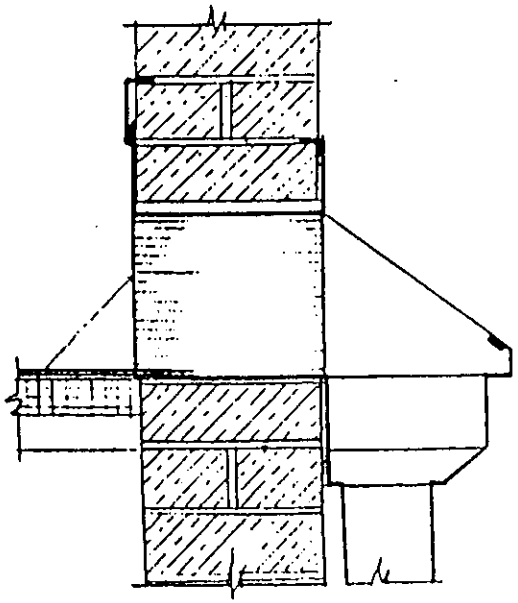
(C) FREQUENTLY CHECK AND CLEAN GUTTERS AND DOWNSPOUTS TO INSURE OPEN, FREE FLOW OF DRAINAGE. ALSO CHECK SPIKES AND FERRULES, STRAP ANCHORS, AND OTHER FASTENERS. TIGHTEN OR REPLACE AS REQUIRED TO HOLD THESE ELEMENTS SECURELY IN PLACE. CHECK LAP JOINTS IN GUTTERS FOR LEAKS. APPLY SILICONE CAULKING ON INSIDE OF GUTTER, AND SMOOTH SURFACE TO AVOID RIDGES.

20 MINUTE BREAK

METAL SCUPPER



ELEVATION



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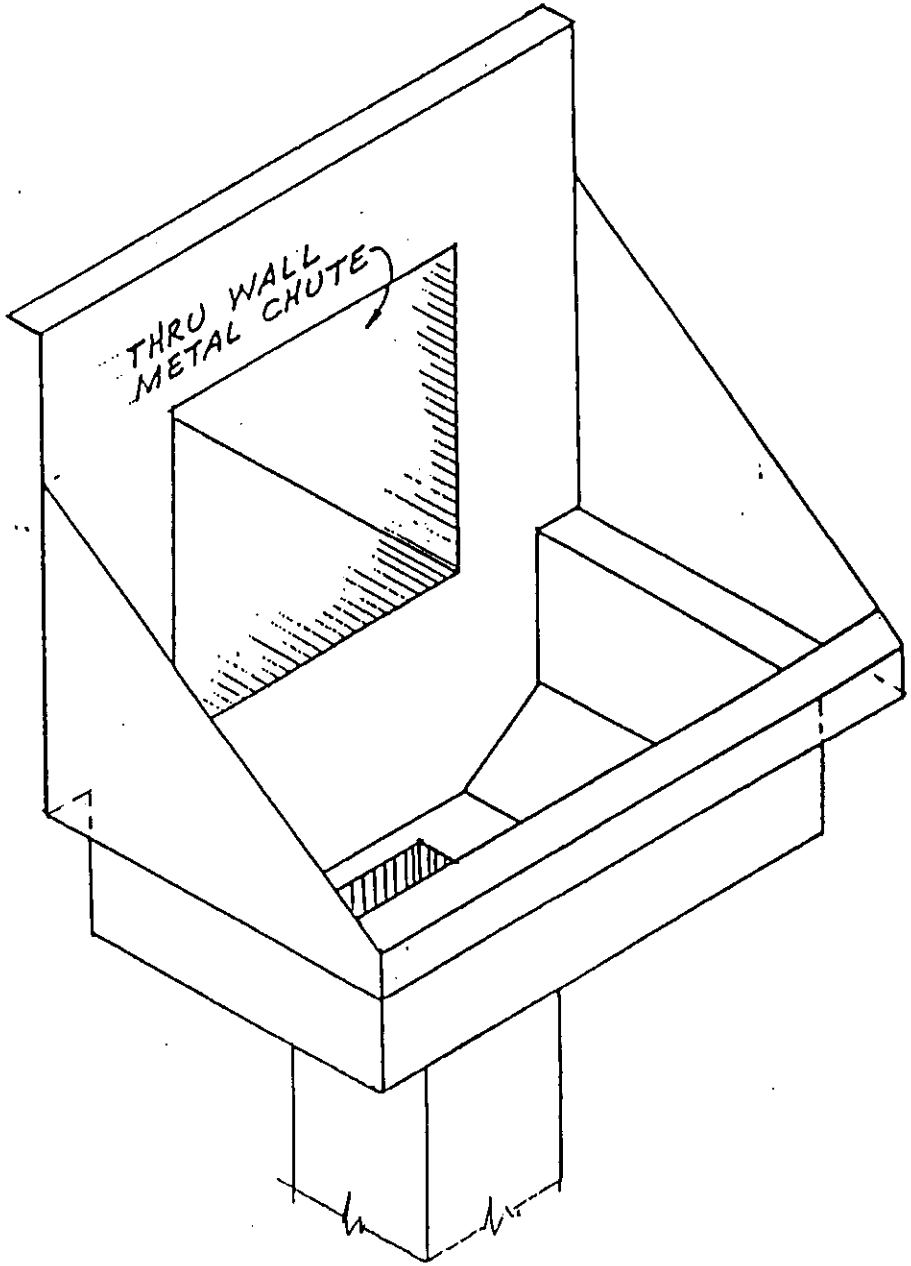
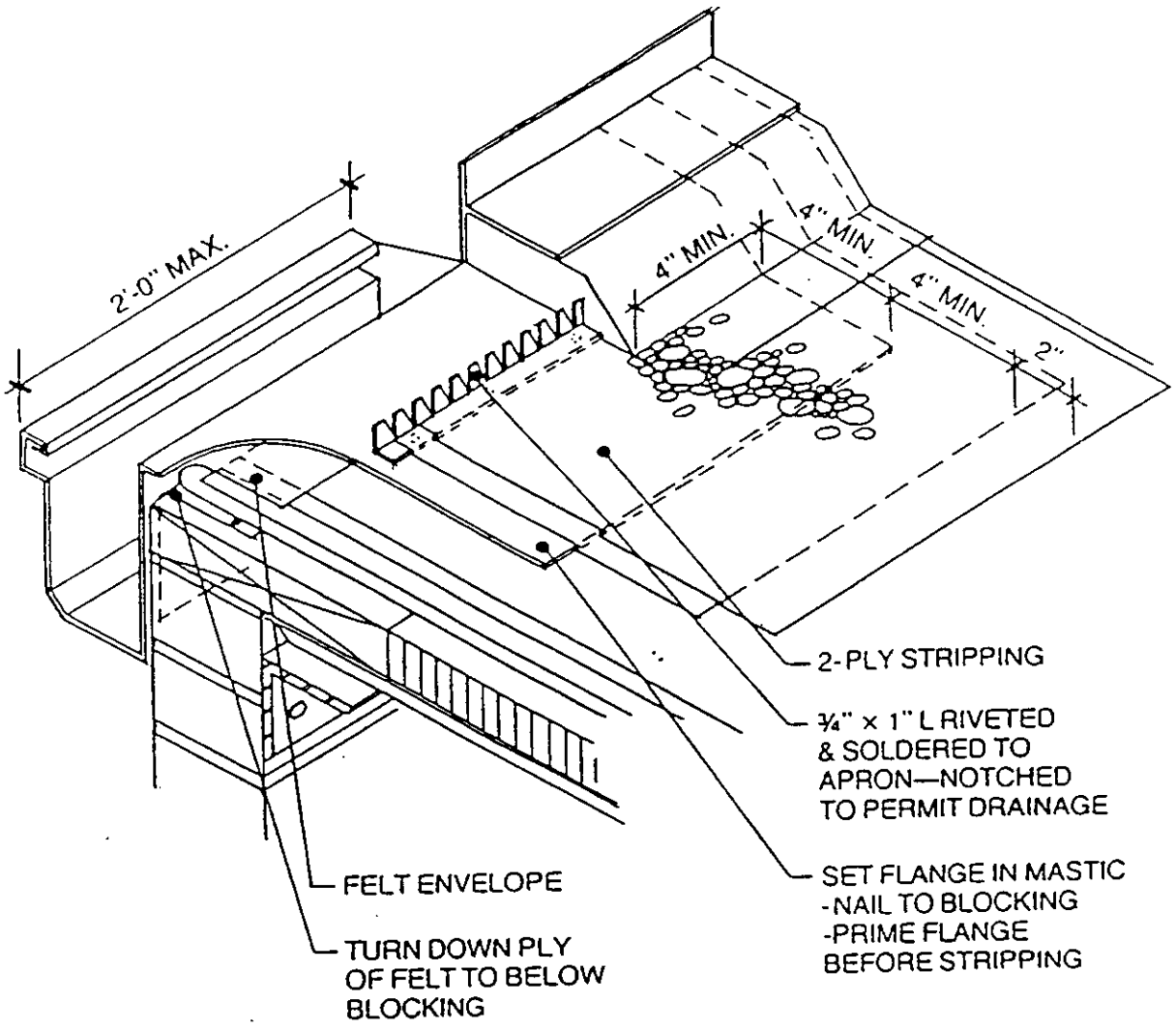


RM 5-15

SCUPPER THROUGH ROOF EDGE



NOTES:

THIS DETAIL SHOULD BE USED ONLY WHERE THE DECK IS SUPPORTED BY THE OUTSIDE WALL.

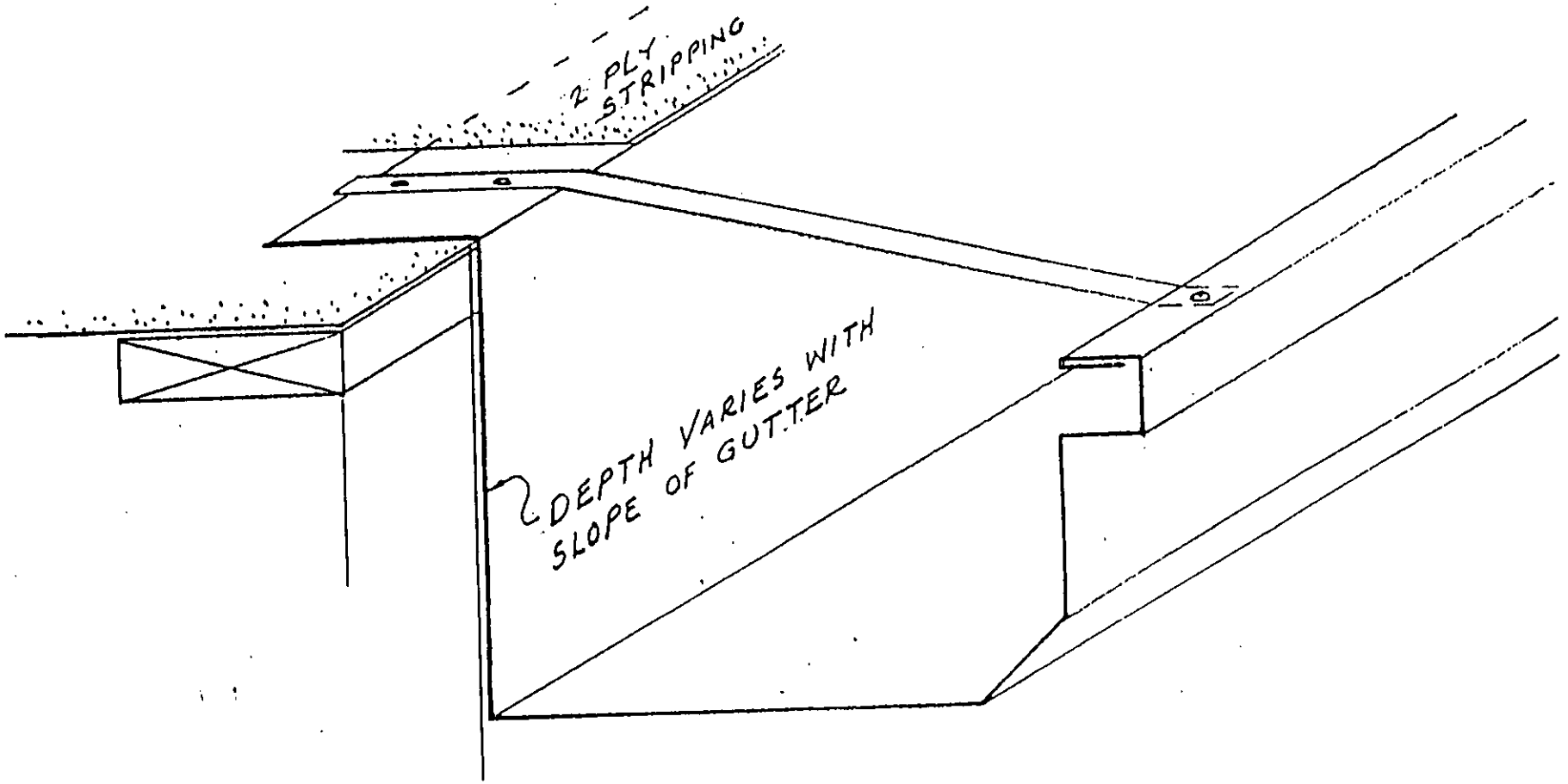
THIS DETAIL CAN BE ADAPTED TO ROOF EDGES SHOWN IN DETAILS "G" AND "O" AND IS EASY TO INSTALL AFTER THE BUILDING IS COMPLETED. THIS DETAIL IS USED TO RELIEVE STANDING WATER IN AREAS ALONG THE ROOF EDGE. ALL ROOF SURFACES SHOULD BE SLOPED TO DRAIN.

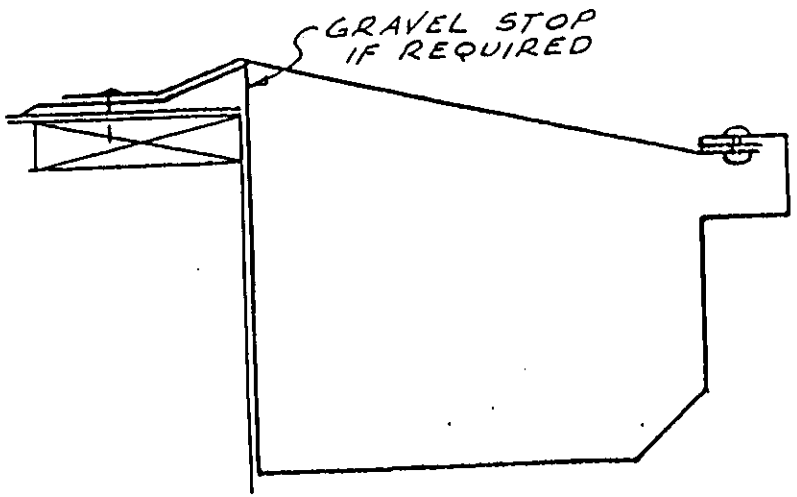
ATTACH NAILER TO MASONRY WALL. REFER TO FACTORY MUTUAL DATA SHEET 1-49.

WOOD BLOCKING MAY BE SLOTTED FOR VENTING WHERE REQUIRED.

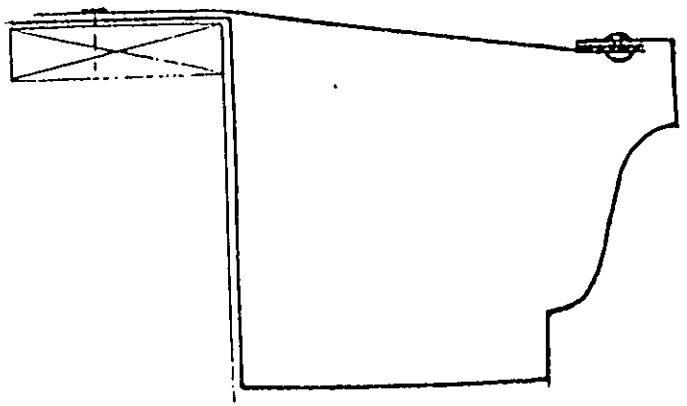
1980

B





INDUSTRIAL BOX GUTTER



RESIDENTIAL GUTTER

RM 5-17

(B) THE CAUSE OF CLOGGING IS THE SAME AS ROOF DRAINS AND SCUPPERS. THE CAUSE OF LOOSE ANCHORS AND LAP JOINTS IS USUALLY 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.

20 MINUTE BREAK

LESSON 6

ROOF MAINTENANCE

3:10 to 5:00

MAINTENANCE VS. REPLACEMENT

AND REVIEW OF ROOF MAINTENANCE

LESSON PLAN 6

1. SUBJECT: ROOF MAINTENANCE

2. OBJECTIVES: TO STUDY THE COSTS OF MAINTENANCE VS. REPLACEMENT OF ROOF SYSTEM. ALSO GENERAL REVIEW OF MAINTENANCE PROGRAM.

3. LESSON OUTLINE:

	SUBJECT	TIME REQUIRED
(A)	INTRODUCTION	5 MINUTES
(B)	ADVANTAGES OF EXTENDING ROOF LIFE	15 MINUTES
(C)	SIMILARITIES & DIFFERENCES IN MEMBRANES	10 MINUTES
(D)	INSULATION	15 MINUTES
(E)	THE DECISION TO RE ROOF	10 MINUTES
(F)	RE ROOFING PROBLEMS STR/COV SPACE LOAD CARRYING A	15 MINUTES
(G)	REVIEW & SUMMARY	40 MINUTES
	TOTAL	110 MINUTES

4. TRAINING AIDS:

(A) 35 MM SLIDE PROJECTOR

(B) OVERHEAD PROJECTOR

(C) SCREEN

5. MAINTENANCE VS REPLACEMENT AND REVIEW

(A) INTRODUCTION (5 MINUTES)

DISCUSS THE ADVANTAGES OF EXTENDING ROOF LIFE VS REPLACING THE ROOF. OUTLINE POINTS TO BE COVERED.

(B) ADVANTAGES OF EXTENDING THE ROOF LIFE (15 MINUTES)

TOUCH ON THE MANY ADVANTAGES OF EXTENDING THE LIFE OF THE ROOF. POINT OUT THE MANY WAYS THAT MAINTENANCE MAKES THIS POSSIBLE.

(C) INSPECTION EQUIPMENT (5 MINUTES)

AT THIS TIME A COMPLETE INVENTORY OF THE INSPECTION EQUIPMENT SHALL BE MADE AND PROVISIONS EXPLAINED FOR GETTING IT SAFELY ONTO THE ROOF.

(D) EVERYONE ON THE ROOF (5 MINUTES)

THE INSTRUCTOR SHALL LEAD THE GROUP ONTO THE ROOF, EXPLAINING AS HE DOES SO THE PROPER WAY TO CLIMB A LADDER.

(E) THE ROOF INSPECTION (80)

THE INSTRUCTOR WILL PROCEED TO LEAD THE CLASS THROUGH THE EXAMINATION OF THE VARIOUS PARTS OF THE ROOF SYSTEM AS DESCRIBED IN THE LESSON OUTLINE.

(F) EVERYONE SAFELY OFF THE ROOF.

20 MINUTE BREAK BEFORE NEXT CLASS

MAINTENANCE VS. REPLACEMENT

BEFORE THE QUESTIONS CAN BE ANSWERED PROPERLY, IT IS NECESSARY TO REVIEW SOME OF THE THINGS WE HAVE LEARNED ABOUT MAINTENANCE. FIRST, MAINTENANCE SHOULD START EVEN BEFORE THE ROOF IS BUILT WITH A GOOD DESIGN FOR THE COVERING OF THE SPACE TO BE ENCLOSED. A PROPER DESIGN WILL LAST A LOT LONGER THAN A "MAKE DO" DESIGN AND IN THE LIFE CYCLE COST OF THE BUILDING WILL BE MUCH MORE ECONOMICAL. NO MATTER HOW WELL THE ROOF IS DESIGNED, IT STILL MUST BE MAINTAINED. WITHOUT MAINTENANCE, AS WE HAVE DISCUSSED BEFORE, SMALL PROBLEMS BECOME BIG PROBLEMS AND AFTER THAT, THE CHOICE IS OUT OF THE OWNER"S HANDS.

UNFORTUNATELY, THE STATE OF FLORIDA HAS A TOTAL DISINCENTIVE FOR MAINTENANCE BUILT INTO CURRENT OPERATING REGULATIONS FOR SCHOOLS. THIS IS A STATEMENT THAT IF A ROOF IS 6 YEARS OLD AND CERTIFIABLY BEYOND ECONOMICAL REPAIR (SO CERTIFIED BY AN ARCHITECT OR ENGINEER), THE STATE WILL CONTRIB-. UTE TO THE REPLACEMENT OF THAT ROOF. IN THE LAST TWO LEGISLATURES, THE FLORIDA ROOFING AND SHEET METAL ASSOCIATION (FRSA) HAS MADE A DETERMINED EFFORT TO CHANGE THIS. THEIR EFFORT HAS BEEN TO PUT A LAW ON THE BOOKS TO THE EFFECT THAT, IF A ROOF IS NOT MAINTAINED, WITH PROPER RECORDS KEPT, THEN WHEN IT BECOMES UNSERVICEABLE, THE SCHOOL BOARD THAT WAS CHARGED WITH MAINTAINING IT IS EXPECTED TO REPLACE IT.

THIS BILL FAILED ON BOTH OCCASIONS. AS A RESULT, IT IS FELT THAT A LOT OF ROOFS ARE BEING REPLACED THAT SHOULD HAVE HAD THEIR USEFUL LIVES EXTENDED BY PROPER MAINTENANCE.

THERE IS A TIME BEYOND WHICH A ROOF CANNOT BE REPAIRED AND MUST BE REPLACED. IT IS TO THE OWNERS BENEFIT TO DELAY THAT TIME AS LONG AS

POSSIBLE. THERE ARE SEVERAL REASONS FOR THIS AND MOST OF THEM HAVE TO DO WITH MONEY.

FIRST, A REPLACEMENT ROOF WILL ORDINARILY NOT LAST AS LONG AS A NEW ROOF OF EQUAL QUALITY. SOME OF THE REASONS FOR THIS HAVE TO DO WITH THE FITTING OF COUNTER FLASHINGS, THE NEED TO RE ROOF IN SUCH A WAY AS TO MAKE PROTECTION OF CONTENTS MORE IMPORTANT THAN CONTINUITY OF THE MEMBRANE. THERE IS ALSO THE NEED TO RESET EQUIPMENT ITEMS ON THE ROOF AND WORK AROUND DRAINS OF PREVIOUSLY ESTABLISHED ELEVATION.

THEN THERE IS THE PROBLEM OF COST. A REPLACEMENT ROOF WILL USUALLY COST 4 TO 5 TIMES AS MUCH AS IT COST TO ROOF THE AREA ORIGINALLY. THIS IS A RESULT OF HAVING TO REMOVE THE OLD ROOF WITHOUT DISTURBING THE REST OF THE BUILDING, OF HAVING TO WORK IN RESTRICTED AREAS AND OF HAVING TO PROTECT THE BUILDING CONTENTS DURING THE ENTIRE OPERATIONS. ALSO, AT THE TIME OF THE ROOF JOB, ANYTHING TO DO WITH MOVING AND RESETTING EQUIPMENT BECOMES PART OF ROOFING COSTS INSTEAD OF H-VAC, TV OR WHATEVER, THIS IS A GOOD TIME TO CORRECT DESIGN DEFICIENCIES THAT PUT EQUIPMENT ON THE ROOF. THE EQUIPMENT SHOULD BE RELOCATED SOMEWHERE (ANYWHERE) ELSE.

STILL ANOTHER REASON TO AVOID AS LONG AS POSSIBLE THE REPLACEMENT OF THE ROOF IS THE SIMPLE FACT THAT A REPLACEMENT ROOF WILL NOT GIVE AS GOOD SERVICE AS AN ORIGINAL ROOF OF THE SAME TYPE, FOR MOST OF THE SAME REASONS THAT IT WILL NOT LAST AS LONG. NEW FLASHINGS HAVE TO BE FITTED TO OLD COUNTERFLASHINGS, ETC.

WITH THESE MONEY INCENTIVES IN MIND, LET US REVIEW THE FACTORS INVOLVED IN THE PROPER MAINTENANCE OF A BUILT UP ROOF.

MAINTENANCE OF BUILT UP ROOFS COVERS THE CARE OF THE MEMBRANE, THE INSULATION, AND THE FLASHING. THERE ARE TWO MAIN TYPES O MEMBRANES, ASPHALT BASED AND COAL TAR BASED. THERE ARE SOME DIFFERENCES IN THESE BUT MANY SIMILARITIES.

LET US DISCUSS THE SIMILARITIES FIRST.

THE BASIS OF ALL ROOF MAINTENANCE IS AN INSPECTION AT LEAST ONCE A YEAR. BEST PRACTICE CALLS FOR THE INSPECTION TO BE MADE TWICE A YEAR WITH SPECIAL INSPECTIONS AFTER ANY PARTICULARLY UNUSUAL WEATHER, SUCH AS A HURRICANE, A WINDSTORM, OR HAIL.

AT ALL THESE INSPECTIONS, A CHECK LIST SHOULD BE CARRIED BY THE INSPECTOR (APPENDIX A) AND FITTED IN TO SHOW THE TIME OF THE INSPECTION, REPAIRS THAT NEED PROMPT ATTENTION, REPAIRS THAT WILL NEED ATTENTION IN A SHORT TIME AS WELL AS HOUSEKEEPING CHORES PERFORMED AT THIS TIME SUCH AS DRAINS CLEANED, LOCATIONS OF MINOR CAULKING REPAIRS, ETC.

THESE MINOR REPAIRS AND HOUSEKEEPING, WHEN DONE AT OR SHORTLY AFTER THE SEMI-ANNUAL INSPECTIONS, DO A GREAT DEAL TO KEEP MINOR PROBLEMS FROM BECOMING MAJOR PROBLEMS. A PIN HOLE IN A FLAT ROOF IS VERY EASY TO REPAIR, BUT LEFT UNREPAIRED FOR A LONG TIME WILL ALLOW WATER TO PENETRATE THE INSULATION. THIS REDUCES THE EFFICIENCY OF THE INSULATION AND ALSO CAN BEGIN TO ROT THE MEMBRANE FROM THE BOTTOM UP. A SIMPLE BUILDUP OF PINE STRAW ON A ROOF CAN CLOG A DRAIN, BACKING THE WATER UP OVER A PIN HOLE CAUSING TROUBLE. REGULAR INSPECTIONS MUST BE MADE AND THE ROOF MUST BE KEPT CLEAN.

AS MENTIONED EARLIER, ASPHALT AND COAL TAR ROOFS REQUIRE A LITTLE DIFFERENT TREATMENT. FIRST, SINCE THE TWO MATERIALS ARE INCOMPATIBLE, IT WOULD BE WISE TO DETERMINE WHICH TYPE OF ROOF IS ON THE BUILDING IN QUESTIONS. FORTUNATELY, THERE IS A VERY SIMPLE TEST TO TELL ASPHALT FROM COAL TAR. SINCE ASPHALT IS A BY PRODUCE OF PETROLEUM DISTILLATION, IT IS SOLUABLE IN THE HIGHER (LIGHTER) DISTILATES OF PETROLEUM. THEREFORE, TAKE A SAMPLE OF THE BITUMEN FROM THE ROOF AND PUT IT IN A JAR AND FILL THE JAR HALF FULL OF KEROSENE OR LIGHTER FLUID. ALLOW TO SIT FOR ABOUT FIFTEEN MINUTES THEN SHAKE VIGOROUSLY. IF THE COLOR BECOMES DARK BROWN AND OPAQUE, THE BITUMEN IS ASPHALT. IF THE LIQUID REMAINS ESSENTIALLY CLEAR - POSSIBLY SLIGHTLY GREENISH - THEN THE MATERIAL IS COAL TAR PITCH. ANOTHER WAY TO TELL THE MATERIALS APART INVOLVES THE USE OF A WELL TRAINED NOSE.

BOTH COAL TAR PITCH AND ASPHALT NEED TO BE PROTECTED FROM DIRECT RAYS OF THE SUN. ASPHALT, IN PARTICULAR, IS VERY SUBJECT OF "ALLIGATORING", A FORM OF INTERCONNECTED SHRINKAGE CRACKS THAT LEAVE THE ROOF LOOKING RATHER LIKE AN ALLIGATORS BACK. THIS IS A PROGRESSIVE PROBLEM, AND ALLOWED TO CONTINUE WILL BARE THE FELTS AND ENCOURAGE WATER TO PENETRATE THEM WILL ALL THE DAMAGE THAT CAN INCUR.

IF THIS ALLIGATORING IS DISCOVERED BEFORE IT PENETRATES TO THE FELTS (AND CERTAINLY SHOULD BE IF THERE ARE SEMI ANNUAL INSPECTIONS) IT CAN AND SHOULD BE CORRECTED. ONCE REPAIRED, THE AREA SHOULD THEN BE PROTECTED BY A FRESH COATING OF STONE.

COAL TAR BITUMEN IS LESS SUSCEPTIBLE THEN ASPHALT TO DAMAGE BY ULTRA VIOLET RAYS. COAL TAR BITUMEN IS ALSO MORE SELF HEALING THAN ASPHALT, HENCE

ALLIGATORING IS NOT QUITE THE PROBLEM WITH COAL TAR THAT IT IS WITH ASPHALT.

THIS SAME SELF HEALING PROPERTY OF COAL TAR, WHICH KEEPS IT MORE FLUID AT LOWER TEMPERATURES, ALSO MAKES IT MORE SUSCEPTIBLE TO SLIPPAGE ON A SLOPED ROOF DECK. AS WE SAID EARLIER, ALL DECKS SHOULD BE SLOPED TO ALLOW FOR DRAINAGE, BUT IN THE CASE OF COAL TAR MEMBRANES, THE SLOPE MUST BE HELD TO A MINIMUM, LEST THE ENTIRE MEMBRANE "DRAIN" FROM THE ROOF.

MAINTENANCE MUST TAKE INTO ACCOUNT THE INSULATION AS WELL AS THE MEMBRANE. INSULATION IS NO PROBLEM AS LONG AS IT SAYS DRY, BUT WHAT ARE THE OPTIONS AFTER IT HAS GOTTEN WET? FIRST THE QUESTION HAS BE ANSWERED "IS THE INSULATION WET AND IF SO, WHERE? " THERE ARE SEVERAL WAYS TO TELL IF INSULATION HAS GOTTEN WET AND EACH HAS ITS OWN PLACE IN PROPER ROOF MAINTENANCE.

FIRST WOULD BE A LEAK INSIDE THE BUILDING. IF THERE IS INSULATION UNDER THE MEMBRANE AND ON TOP OF THE DECK, SOME OF IT GOT WET WHEN WATER PENETRATED FROM THE ROOF SYSTEM. IF THERE IS ALSO A VAPOR BARRIER AS A PART OF THAT ROOF SYSTEM, IT IS LIKELY THAT IN ADDITION TO A LEAK IN THE ROOF THERE IS A PROBLEM WITH WET INSULATION. HOW MUCH WET INSULATION IS THERE?

TO DETERMINE THE ANSWER TO THAT QUESTION, SOME SORT OF ROOF SURVEY IS IN ORDER. THE TWO MOST COMMON SURVEY METHODS ARE INFRA RED AND WITH THE USE OF NUCLEAR MOISTURE METERS. BOTH OF THESE METHODS ARE APPROXIMATE, BUT THEY WILL USUALLY GIVE SUFFICIENTLY ACCURATE RESULTS TO INDICATE WHERE SOME PLUGS SHOULD BE CUT TO DETERMINE THE LIMITS OF THE WET INSULATION.

MORE AND MORE PEOPLE ARE COMING AROUND TO THE IDEA, SHARED BY THE AUTHOR, THAT THE PROPER THING TO DO WITH WET INSULATION IS TO REPLACE IT. WHILE THIS MEANS CUTTING AWAY AND REPLACING A PART OF THE MEMBRANE, IT DOES GIVE THE REPAIR TEAM A CHANCE TO EXAMINE THE DECK AND CHECK FOR DAMAGE THERE. (THIS IS A DISTINCT POSSIBILITY WITH GYPSUM AND WITH LIGHT STEEL DECKS)

AS WE HAVE MENTIONED BEFORE AND MAY MENTION AGAIN, PENETRATIONS ARE LIKELY PLACES TO FIND LEAKS. THEREFORE, EVERYTHING RELATED TO MAINTENANCE SHOULD TAKE INTO CONSIDERATION THE FLASHINGS USED WITH HE BUILT UP MEMBRANE. FLASHINGS SHOULD BE MADE OF THE SAME MATERIAL AS THE MEMBRANE AND COUNTER FLASHINGS SHOULD BE MADE WITH METAL. UNFORTUNATELY, THIS PRACTICE HAS NOT ALWAYS BEEN OBSERVED AND A NUMBER OF OLDER BUILDINGS (AND SOME NEW BUILDINGS WITH OLD SPECIFICATIONS) HAVE SUCH THINGS AS GRAVEL STOPS LAMINATED INTO THE ROOF PLYS. THE PROBLEM HERE IS THAT THE COEFFICIENT OF EXPANSION IS QUITE DIFFERENT FOR THE ROOFING MEMBRANE AND FOR THE EMBEDDED FLASHING. THIS SITUATION CAUSES THE FLASHING TO DESTROY THE MEMBRANE IT WAS DESIGNED TO PROTECT.

AT EACH MAINTENANCE INSPECTION CLOSE ATTENTION SHOULD BE PAID TO THE CONDITION OF THE FLASHING. MINOR CORRECTIONS AND TOUCH UP IN THIS AREA OF THE ROOF IS MOST REWARDING IN EXTENDING ROOF LIFE AND ALLROUND BETTER SERVICE OF THE WHOLE MEMBRANE.

THERE WILL COME IN THE LIFE OF EVERY ROOF A TIME WHEN THE ROOF MEMBRANE HAS SERVED OUT ITS USEFUL LIFE AND IT NEEDS TO BE REPLACED. THIS TIME OCCURS WHEN THE ROOF IS NO LONGER DOINGS ITS JOB AND THE COST OF REPAIRING IT EXCEEDS THE COST OF REPLACING IT.

FREQUENTLY, THERE IS A TEMPTATION TO REPLACE A FAILED ROOF WITH SOMETHING "NEW AND BETTER". WE WILL DEAL WITH THAT PROBLEM LATER, FOR NOW WE ARE CONCERNED WITH THE BUILT UP ROOF. LET US MAKE ONE NOTATION AT THIS TIME - THAT NEW IS NOT NECESSARILY BETTER.

ONCE THE DECISION HAS BEEN MADE TO RECOVER THE ROOF AREA OF THE BUILDING, THERE ARE OTHER DECISIONS THAT MUST BE MADE. ONE IS TO COVER THE OLD ROOF OR STRIP IT DOWN TO THE DECK. THERE ARE SEVERAL FACTS THAT MUST BE CONSIDERED IN THIS DECISION. FIRST, RECOVERING THE OLD ROOF, IF THAT IS PRACTICAL, OFFERS LESS CHANCE OF LETTING RAIN INTO THE BUILDING. IF, ON THE OTHER HAND, THE INSULATION IS WET, AND/OR THE DECK NEEDS EXTENSIVE REPAIR, IT MAY BE NECESSARY TO STIP THE OLD ROOF ENTIRELY. ANOTHER FACTOR THAT MUST BE CONSIDERED AT THIS POINT IS THE DESIGN LIVE AND DEAD LOADS. IF THE DESIGN DEAD LOAD WAS USED UP BY THE FIRST ROOF, AND PARTICULARLY, IF THAT ROOF SYSTEM NOW HAS SOME WATER IN IT, THEN THE QUESTION MUST BE ANSWERED," IS THERE ENOUGH LIVE LOAD TO CARRY THIS NEW ROOF PLUS ANY REQUIRED LIVE LOAD?" THE ANSWER TO THAT QUESTION IS FREQUENTLY BLURRED BY THE LOSS OF THE "AS BUILT" DRAWINGS OF THE ROOF AS WELL AS THE ENGINEER'S ORIGINAL DESIGN. ANOTHER FACTOR THAT ENTERS INTO THE DECISION MAKING PROCESS IS CONSTRUCTION LOADS. EVEN IF THE ROOF HAS ENOUGH LOAD CARRYING ABILITY TO TAKE CARE OF THE WEIGHT OF THE NEW ROOF AND STILL HAVE E A MARGIN FOR 20 LB PER SQUARE FOOT LIVE LOAD, IT IS ENTIRELY POSSIBLE THAT CONSTRUCTION LOADS WILL EXCEED THE 20LB PER SQUARE FOOT LIVE LOAD. A THREE FOOT HIGH PILE OF GRAVEL OR A PALLET OF ROOFING FELT EXERTS PRESSURES FAR IN EXCESS OF 20LB PER SQUARE FOOT.