CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE-247667 (INDIA)

BUILDING RESEARCH NOTE

B.R.N. 86

LOOSE FILL MATERIALS FOR COLD STORAGE INSULATION

Correct design of thermal insulation system contributes to the efficient and economic operation of cold storage spaces. A survey of some of the cold storages in Northern India and West Bengal was conducted by the Central Building Research Institute, Roorkee, to collect information on their structural and insulation practices with a view to evolving efficient and economical thermal designs. The survey indicates that cold storages use sawdust, rice husk, thermocole and fibreglass as insulating materials. Since the cost of the sawdust and rice husk are much lower, most of the cold storage owners prefer to use these materials inspite of some of their drawbacks.

This Building Research Note aims to provide necessary back-ground information for these cheaper type of insulations, vapour barriers and the correct method of application. A few methods have also been suggested by which thermal efficiency, moisture absorption and other properties can be improved. These include the treatment of these materials with water resistant-coating and mixing exfoliated vermiculite in suitable proportion.

Types of Insulation

The primary requirement of thermal insulation in cold storage construction is to minimise the initial cost of refrigeration as well as the running expenses. The risk of moisture condensation should also be avoided.

Insulation materials may be broadly classified as : (a) fibrous materials such as glass-wool, rock-wool and fibreglass, (b) loose fill insulation , such as rice husk, sawdust and exfoliated vermiculite (c) cellular organic materials like expanded polystyrene, cork and polyurethane. The most important properties which a cold storage insulation should satisfy are, the thermal efficiency of insulation, resistance to water vapour migration and durability at low temperature. Although initial cost of insulating materials is an important factor, due consideration should be given to various other requirements.

Loose Fill Materials

Loose-fill type of insulation materials can be divided into two classes(1) Non-permeable, non-hygroscopic which neither absorb moisture

nor allow water vapour to migrate through them. Exfoliated vermiculite and thermocole beads are of this category (2) Permeable hygroscopic, this type of materials absorb moisture in humid atmosphere and water vapour can easily penetrate through them. Materials like sawdust, rice husk and coconut pith, fall in this class. The main advantage in using the latter class of materials is that these are locally available and are much cheaper. Moisture absorption by them is due to vapour pressure differential and condensation occurs where ever the vapour pressure is greater than the saturation vapour pressure. Thermal conductivity of these materials depend upon density, moisture contents, mean temperature and direction of heat flow. There is an optimum density at which thermal conductivity is minimum. Thermal conductivity values for different density of packing are given in table 1. Moisture absorption for these materials depends upon the temperature and relative humidity. In hot dry climate the normal moisture content varies from 6 to 8 percent by weight. But in hot humid climate it can reach upto 18 to 20 percent by weight. Once moisture contents are known correction factors can be applied by the use of table 2.

Thickness of insulation required for wall, roof and floor sections are very much different. Economical thickness of insulation to satisfy the requirements of Indian Standard Code of Practice (IS-1964) have been worked out and are given in table 3.

Vapour Barrier

Vapour barrier is defined as any material which has water vapour transmission rate of less than unity. It should always be applied on the hot side in sufficient thickness and with care. Film type of vapour barriers are most suited for most of the systems. Joints in films should be properly sealed and their number should be kept minimum. Two coats of bitumen or polyethlene in 400 to 800 gauge may be used. These are found less expensive than aluminium foil. The vapour trans mission rates of few typical vapour barriers are given in table 4.

Application

Careful application of the insulating material is very important since it will improve efficiency. Summer months are most suitable for construction of new cold storages with these materials. Before application insulation materials must be dried in open air for atleast seven days to give off any embedded moisture. The technique of application of various elements of the cold storage structure is described below:

(a) Walls

(1) Wooden pegs of size 10x10 cm (or M.S. angle 4x4 cm) should be fixed on walls at suitable spacings depending upon the size of asbestos sheet or wooden planks available. Wooden or A.C. sheet framing on long walls should first be constructed to form a cavity for taking the insulation.

(2) Clean by brush and dry the surface to be insulated.

(3) Apply two coats of hot bitumen.

(4) After the second coat has cooled down but is still sticky, fix 600 guage thick polythylene to the surface with 7.5 cm overlap.

(5) Fix 3.0 mm thick A.C. sheet or wooden plank on the cold side starting from bottom.

(6) Pour rice husk, sawdust or exfoliated vermiculite in the cavity. Packing density and thickness should be maintained as given in tables 1 and 3. It is not necessary to pack it tightly.

(7) Continue the process of filling and packing the material in the same manner upto the ceiling level.

(8) Seal all joints on the cold side with (1:6) cement sand plaster.

(b) Floors

(1) Clean the surface.

(2) Apply hot bitumen on the surface and fix 2 layers of tarfelt with 7.5 cm overlap, Sealing all joints with hot bitumen.

(3) Fill the insulation preferably at a density and thickness as given in tables 1 and 3.

(4) Fix 12.0 mm thick wooden planks or particle board across the pegs on battens.

(5) Apply 5.0 cm thick concrete screed.

(c) Ceiling

It is necessary to provide a false ceiling in case of sloping roofs.

(1) Clean the wall surfaces below the roof upto a depth of 50.0 cm.

(2) Apply two coats of hot bitumen on the surface of the ceiling.

(3) After the second coat has cooled down but is still sticky, fix 600 gauge thick polyethylene on the surface with 7.5 cm overlap and 20.0 cm projecting out wards.

(4) Fix wooden plank, particle board or A.C. sheet on wooden battens and pour the insulating material. The density and thickness should be as given in table 1 and 3.

(5) Cover the upper surface of the insulation towards hot side with 400 gauge polyethylene sheet with 7.5 cm overlap. Seal all joints with hot bitumen.

(6) Seal all joints on the cold side with (1:6) cement sand plaster.

Although, use of film vapour barrier involves additional cost, the total cost of the insulation system is comparatively less than one used in conventional method. The main saving is in labour and material. It also ensure s slightly more storage space and prolongs life and duration of these materials in the cavity.

Effect of Treatment with Water Proofing Materials

Thermal efficiency, moisture absorption, life and other properties of insulation materials like rice husk and sawdust can be improved by coating these with water resistant materials. These properties can also be improved by packing in polyethylene bags or mixing them with exfoliated vermiculite in a suitable proportion. The results of various treatments are given in table 5. Although by these additional treatments, the cost of insulation system is raised to a certain extent, the increase in the overall cost of the insulation system is not more than 20 percent. Even after such treatments of the cheap variety of insulation materials the overall cost of insulation system is lower than what would be needed for thermal insulation like thermocole, mineral wool and fibreglass. In hot humid climate the use of materials treated with any of the methods suggested above will certainly improve efficiency and life. Hygroscopic materials should be fully dried before giving any of these treatments.

Table 1
Thermal Conductivity Values of Loose Fill Materials under Oven Dry Condition

S. No.	Density Kg/m^3	Thermal Conductivity - W/mK		
		Saw-dust	Rice-husk	Exfoliated vermiculite
1	120	0.0709	0.0639	0.0581
2	140	0.0628	0.0593	0.0628
3	160	0.0593	0.0581	0.0663
4	180	0.0605	0.0628	—
5	200	0.0663	0.0709	—

Table 2
Correction Factor due to Moisture Contents on Thermal Conductivity Values

S. No.	Percentage Moisture Content by Weight	Correction Factor		
		Saw-dust	Rice-husk	Exfoliated Vermiculite
1	1.0	1.06	1.05	1.03
2	2.5	1.15	1.12	1.08
3	5.0	1.30	1.25	—
4	10.0	1.50	1.41	—
5	15.0	1.65	1.62	—
6	20.0	1.71	1.72	—

Table 3
Recommended Thickness of Insulation for Potato Cold Storage

S. No.	Name of material	Thickness in Centimeters		
		Walls	Roof	Floor
1	Saw-dust or Rice-husk	25.0	30.0	20.0
2	Exfoliated Vermiculite	15.0	15.0	10.0
3	Thermocole	7.5	8.0	5.0
4	Fibreglass or Mineral Wool	7.5	8.0	5.0
5	Cork	7.5	8.0	5.0

Table 4
Vapour Transmission Rates of Vapour Barriers and Materials

S. No.	Name of Materials	Permeance in perm
1	Polyethylene 800 gauge	0.04
2	Polyethylene 600 gauge	0.06
3	Polyethylene 400 gauge	0.10
4	Bitumen coating (2 coats)	0.10
5	Aluminium foil (100 gauge)	0.04
6	Tarfelt, 2 layers	0.08
7	Asbestos sheet, 6.0 mm thick	4.80
8	Plywood, 6.0 mm thick	5.20
9	Cement sand plaster, 1.25 cm thick	10.21
10	Brick work, 20.0 cm thick	0.65

Table 5
Effect of Treatments on Saw-dust and Rice-husk

S.No.	Type of Treatments	Rice-husk Saw-dust	Density Kg/m^3	Moisture Absorption (per cent by weight)		Water Vapour Permeance (perm)	Corrected Thermal Conductivity (W/m K)
				70% R.H.	100% R.H.		
1	Untreated	R	150	8.2	17.4	12.6	0.0988
		S	200	9.3	19.0	14.5	0.1163
2	Treated with 10% by weight of Bitumen	R	167	6.1	8.0	8.6	0.0756
		S	225	6.4	8.3	9.2	0.0988
3	Packed in polyethylene bags of size 30 × 30 × 15 cm	R	151	2.2	3.8	2.2	0.0698
		S	203	2.7	4.4	2.9	0.0814
4	Treated with 5% solution of Sodium Stearate	R	150	7.3	14.0	11.9	0.0872
		S	200	8.8	16.5	13.4	0.1047
5	Treated with (4) and packed in polyethylene bags	R	152	2.0	3.7	2.2	0.0581
		S	204	2.5	4.3	2.7	0.0756
6	Mixed with 10% by weight of Exfoliated Vermiculite	R	148	5.8	8.0	7.5	0.0814
		S	196	6.0	9.5	8.4	0.0988

R Rice husk
S Saw-dust

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