

<http://ansinet.com/itj>

ITJ

ISSN 1812-5638

# INFORMATION TECHNOLOGY JOURNAL

**ANSI***net*

Asian Network for Scientific Information  
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

## External Wall Insulation Technology Research in Building Technology

Yun Ma and Hua Si

Department of Civil Engineering and Architecture, Xinxiang University, 453000, Xinxiang, China

**Abstract:** In this era, both in food and clothing, or live line, everyone has the idea of sustainable development are pursuing environmental protection and energy saving. With the gradual improvement of the overall quality of our people and living conditions rapidly changing, in order to energy saving and environmental protection, improving the utilization rate of energy is more and more concerned by the vast number of new generation "house owners". Also, with the latest introduction of building energy efficiency standards, building has developed from people to solve housing problems of minimum requirements to more advanced green ecological building. In architecture, the loss of the outer structure is relatively large, so the building external wall insulation technology development is one of the most important aspects of strengthening the construction of energy-saving technologies and the development of exterior wall thermal insulation technology is an important way to realize the building energy saving and environmental protection.

**Key words:** Construction technology, exterior wall thermal insulation technology, building energy efficiency

### INTRODUCTION

Since 1986, China began to implement the first a building energy efficiency design standards, building energy conservation is still no comprehensive implementation. According to statistics, China's current building area more than 42 billion square meters, most of these buildings were built in the 1980 and 1990s, which can really achieve the new implementation of building energy efficiency standards are less than two hundred million square meters, only accounted for 0.04% of the area of the existing building. By contrast, Europe and the United States and other developed countries has put forward new energy-saving standard for new public buildings and previous housing reform, the exterior wall is generally efficient insulation material combined with the wall structure technology. However, in China, most of the external walls of the building, namely palisade structure thermal performance is relatively poor and compared with other climate similar countries, in the external walls, windows, the roof of the heat transfer coefficient is higher than these countries 3-5 times and the doors and windows of air leakage coefficient is higher than other countries 3-6 times. This caused a lot of unreasonable energy consumption, our country has become a big building energy consumption country because of vast territory and huge population, in the building energy consumption our country is still at the preliminary stage of development, there is still a certain gap compared with the developed countries.

Our country in exterior insulation development started relatively late. Through twenty years

development, the policy has long been put forward "three steps" of skill building, the first step is to realize energy saving 30%, the second step is to realize energy saving 50%, the third step is to realize the goal of energy saving 65%. And in the past 20 years, the strengthening of the external thermal insulation technology, which has become the main insulation way in north China region (Oluwole *et al.*, 2012).

Winter in the north, the energy-saving will mainly affect the indoor temperature, the housing construction with bad insulation effect will feel cold, while in the summer, bad indoor thermal insulation will make human feel too hot. In other words, the external wall insulation technology is a fundamental method to improve the indoor environment. But at the same time improve the external wall insulation technology should take the way of saving heating and energy consumption, energy efficient can also strengthen the maintenance of the structure (including the external walls, windows, roof and ground) and has the performance of moisturizer and insulation, at the same time can raise the air tightness of the windows and doors external insulation materials.

External wall insulation is that fix reduced thermal conductivity insulation materials and building external wall into a whole one, in order to increase the thermal resistance of the wall, so as to achieve the effect of heat insulation and heat preservation. According to the insulation materials different setting position, the type of exterior wall thermal insulation can be divided into external insulation, interior insulation and sandwich external wall insulation. The development trend of external wall insulation technology is shown as Fig. 1.

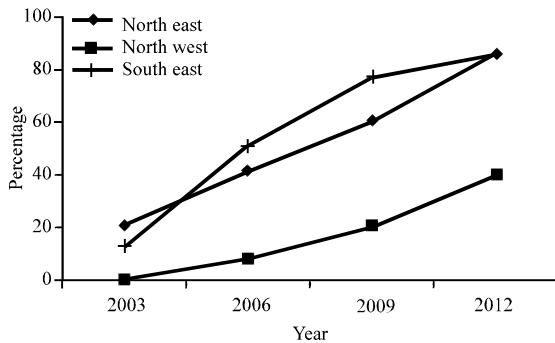


Fig. 1: Development trend of external wall insulation technology

### TYPE OF EXTERIOR WALL THERMAL INSULATION

**Exterior wall exterior thermal insulation:** The full name of external thermal insulation is exterior wall exterior thermal insulation. Exterior insulation is put thermal insulation system out of wall lateral, enables it to achieve the purpose of insulation.

The advantages of external thermal insulation:

- **Wide application scope:** Exterior insulation is not only suitable for the north building heating, also apply to air-conditioning in the South building, moreover, it is suitable for high and low buildings, new buildings and the transformation of the old buildings (Thamer *et al.*, 2012)
- **Reduce the occurrence of thermal bridges:** Because the effective thermal insulation layer in the external wall lateral, make the hotline bridge problem greatly reduced. At the same time also can effectively prevent the thermal bridge condensation problems. In the same heat preservation material conditions, the external thermal insulation reduced about 20% of the heat loss than the inner insulation, better to save energy
- **Extend the life of the main body structure:** The insulation layer in the external walls of buildings, as to give the buildings a coat, the stress generated by the structural deformation caused by temperature changes, as well as to avoid structural damage caused by rain, snow and other weather phenomena, also reduce erosion of harmful gases and ultraviolet radiation on the exterior structure, improve service life and reduce the long-term maintenance costs
- **Wall moisture improved:** Exterior insulation method, due to the high permeability of the neat themes

structural material is placed inside of the insulation layer, as long as the insulation material selection and generally does not occur condensation inside the wall, so there is no need to set the vapor barrier. After use exterior insulation measures, the entire wall of the structure layer temperature increase reduce the amount of heat it, the insulation properties of the wall has been improved

- **Keep the indoor temperature stability, improving the indoor environment:** Temperature changes often lead to the frail elderly and a child sick, outer wall insulation due to the regenerative ability of the structure layer is placed in the wall inside of the indoor air temperature rises, when the indoor suffered unstable thermodynamic effects, the indoor air temperature or the increase or decrease, the structural layer of the wall can absorb or release heat to adjust the indoor temperature and is conducive to the stable room temperature (Herrera *et al.*, 2012)
- **Nice decorative effect:** In the construction process, the polystyrene board can be made into a variety of styles of ornaments, which enrich the appearance of the building
- **Avoid the decoration:** Avoid the decoration destructing the insulation layer (Suwanbamrung *et al.*, 2012)
- **Increase the use of housing area:** Consumers in the purchase of housing are most concerned about is the house using area, in the renovation of housing most concerned about is the impact to the housing area. Due to the outer insulation timely affixed to the outside of the wall, the insulation/heat insulation effect better than the internal insulation, so the theme wall thickness can be reduced, thereby increasing the housing area (Chakraborty *et al.*, 2012)

According to statistics, take Beijing, Harbin, Shenyang, Lanzhou tower as an example, when the solid brick as the main structure, the actual usable area of each household can be increased by 1.2m<sup>2</sup>, 4.2m<sup>2</sup>, 2.4m<sup>2</sup> and 1.3m<sup>2</sup>, significant economic benefits.

The construction area growth after using external thermal insulation is shown as Fig. 2.

Exterior insulation wall not only protect the main wall, the indoor thermal environment has been improved, but also energy effective conservation, so it has a very high overall efficiency of the use of external wall insulation technology.

### Structure and characteristics

**Structure:** External wall insulation technology is put the exterior insulation layer out of building.

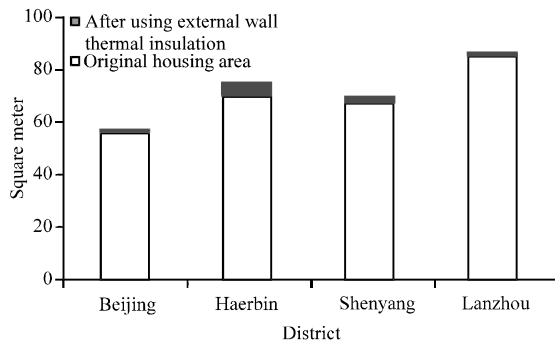


Fig. 2: Construction area growth after using external thermal insulation

- **Characteristics:** A wide range of application in different climate zones
- Thermal insulation effect is remarkable and the "hot bridge less effect"
- Can effectively avoid indoor condensation, mildew and other phenomena and will help to improve the indoor environment
- Expand the interior space, household increase by 1.3 to 1.8 sq<sup>-1</sup> m area
- It can protect the main structure and reduce the impact of external factors on the main structure

### Construction characteristics

- **Primary wall acceptance, then insulation layer construction. steps:** Cleaning, leveling the grassroots-bomb, linked to the Line of Control-the installation, leveling the bottom of the pallet eaves-materials and tools ready, glue-paste Bag turning over Mesh Province paste benzene board-check level-tamponade slab-polished the leveling-install moldings (made with benzene board) or sub-lattice seam-nail the anchoring nails-insulation layer and acceptance (Rahnema and Mirasi, 2012)
- **Paste the polystyrene board's construction points. Paste over packet networks:** Turn over packet networks pasted into the following parts, then sealed waterproof treatment. Around the door and window openings, reserved for the hole, parapets, plinth, balcony, canopy and other, deformation joints and grassroots different structure at the combination of different materials. The above parts called the system terminal. Turning package mesh requirements pushed onto polystyrene board on both sides are not less than 100 mm (Bier, 2012)
- **Point frame method pasted polystyrene board applies to the grassroots flat wall:** The rural poor medical

problems will be run with the trowel slurry evenly coated in polystyrene board around evenly coated in the blanks certain the gray pie, then the polystyrene board at a predetermined position of the bit and even the press at any time to monitor the verticality and flatness, solid, smooth polystyrene board substrate bonding. Polystyrene board flatten the surrounding slurry width of about 60 ram, the narrowest point is greater than or equal to 60 mm, gray cake diameter greater than or equal to 100 ram, thickness 5 mm and the bonding area of not less than 50% of the area of the polystyrene board

- **Point stick law paste the polystyrene board applies to grassroots weakened wall:** By controlling the thickness of each group gum to solve this group gel corresponding not flat wall, uniformly arranged in panels E 9 points, each point of the diameter of 100 ram, 10 mm thick, center distance 200 mm. When using a non-standard size plate, paint bonding glue is generally not more than six points, but should not be less than four points, bonding glue smear area with this edition of the ratio of the area shall not be less than 1.3, to ensure viscose bonding area is larger than or equal to 50% of the surface area of the plate (Serag-Eldin, 2013)
- **Seams and detailed requirements:** The polystyrene board paste should be bottom-up, staggered joint Paste corner bite rub. Each layer break 1/2 plate long not less than 200 ram. Deviations sizes of materials caused by more than 2 mm plate gap. Polyphenylene plates should be stuffed into a suitable small piece cracks. The polystyrene board the four corners of door and window openings should be used full-page cut to shape, can't be spliced. Seams from the four corners of the hole no more than 200 mm. The script plate paste after finish standing 24 h slab uneven sanding flat and then do the next process. After install Polystyrene board anchor a solid paste. According to the requirements with percussion drill hole position, anchorage depth analysis of steel structure engineering construction quality supervision of not less than fifty ram and according to the actual wall material adjusting depth. The wall plaster layer should not be used as anchoring depth. The sun Angle position installed two rows anchor nail. Spacing for 50 era. The first nail should away the wall 10 cm, to prevent the wall damaging
- **Protective layer construction requirements:** Marinated mortar with a trowel evenly coated on the surface of the polystyrene board. Pre-material good mesh positive position with a trowel pressed into the surface mortar is progressive traveling, to avoid

mesh cloth fold. Laying mesh lateral, top-down progressive Stones Paving turn along the exterior wall corner and door and window openings in the hole affixed to a long 300 mm wide 200 ram 45° oblique Mesh. Put the strengthen network on the following sites: The underlying distance the outdoor range parts of a height of two meters above the ground; Buildings yin and yang angle, may suffer from the impact site. Strengthening mesh sticks method: First, post strengthen the network, then paste the standard network and strengthen the network with standard network must be added between wiping a layer of surface mortar. Mesh cloth lap: Standard mesh the lap width greater than or equal to 100 ka; Strengthen mesh cloth don't lap and bent, the side of the net require docking. Corner mesh continuous laying packet transfer width greater than or equal to 200 mm. Twist processing: Can't continuous construction of the working face starter width greater than 100 mm mesh cloth in plaster mortar outside and keep the mesh cloth flat and clean to subsequent construction

**Exterior wall inside insulation:** External wall insulation is the inside of the external walls using benzene board, insulation mortar and other insulation materials, allowing the building to achieve the role in the construction of energy-saving insulation. Exterior wall inside insulation has the advantage of convenient construction, less demanding of the verticality of the external walls and fast construction schedule. Exterior wall insulation also has an obvious defect: The presence of structure cold (hot) bridges make the local temperature difference is too large to produce condensation. Principle: Due to the position of the inner insulation protection wall in the building interior walls and beams inside, interior walls and panels reaction to the lack of effective protection, that is why this part is easy to form cold (hot) bridge, winter indoor temperature of the wall and the indoor corner, that is wall insulation and not insulation board obliquity, the temperature difference is about 10°C, indoor temperature difference can reach more than 15°C, once the indoor temperature conditions are suitable, condensation can occur in this phenomenon. The dew condensation entering or freezing and thawing can easily cause the insulation walls moldy, even cracking.

#### **Structure and characteristics**

**Structure:** The inner insulation is put the insulation material inside of the outer wall.

#### **Characteristics:**

- **Inside insulation advantages:** Decorative surface and waterproofing insulation materials, weather and other

technical standards requirements are relatively low, gypsum board, plaster surface mortar can meet their requirements, drawn aspects

Insulation materials floor separated only in the range of one-storey construction, do not need reaction of scaffolding and other construction facilities. It also has high security and can be used at any climate region.

For the all old buildings can be for energy saving

- **Inside insulation disadvantages:** Ring beam, slab, structural columns will cause thermal bridges, leading to a lot of heat loss. Facing layer due to factors such as material, structure, construction, easily lead to cracking

Compared to the external thermal insulation, internal insulation will occupy part of the indoor space.

To transform the old building, it will interfere with the daily life of residents

The outdoor temperature has great influence on wall, the temperature difference between the relationship will lead to cracks of the wall.

**Exterior wall sandwich insulation:** The external walls sandwich insulation is that during operating construction using exterior insulation in convenient part and inconvenient part using inside insulation, so as to achieve the implementation of the overall insulation of the buildings construction.

**Advantages:** Lower requirements for selection of insulation materials, polystyrene, glass wool, stretches all can consider. Lower construction conditions, also winter can construct.

From the operational point of view, sandwich insulation can speed up the overall construction speed, the interior walls cannot be protected from external wall insulation and the intersection part of the exterior wall cold (hot) bridge make effective protection. However, sandwich insulation also has its serious malady, outside insulation parts of the building is the structure of the main wall by the indoor temperature and the influence of temperature reduction makes wall in a relatively stable temperature range, which leads to the difference in temperature deformation adaptability is relatively small; internal thermal insulation practice site so that the structure of the wall of the building received the major impact of the outdoor ambient temperature, large temperature difference resulting wall is unstable temperature range and it has led to the temperature difference between the deformation adaptability relatively large. Exterior wall sandwich insulation is that make different deformation in different parts of the body of the entire building facade, the building structure is not very

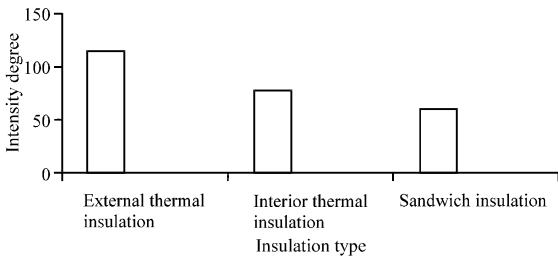


Fig. 3: Relationship of insulation type waterproofness and weatherability

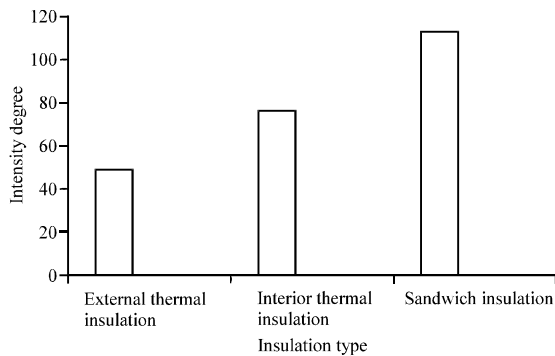


Fig. 4: Relationship of insulation type, Thermal Insulation Heat Insulation

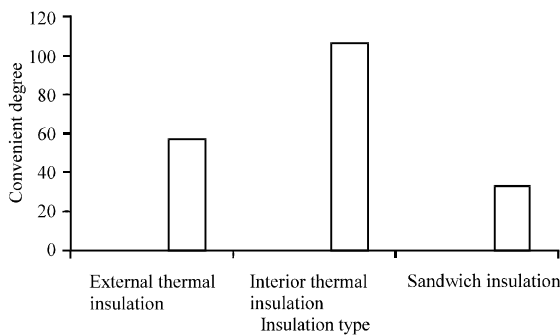


Fig. 5: Relationship of insulation type and construction convenience

stable, the temperature difference between the frequent changes going on the exterior structure of cracks, thus shortening the whole building lifetime.

From the above points, sandwich insulation has been rarely used with the development of external wall insulation technology.

**Construction and characteristic:** The exterior wall sandwich insulation technology insulation materials placed on the same side of the external walls of the inside and outside on both sides, inside and outside side wall piece traditional clay brick, concrete hollow block.

**Advantages of sandwich insulation technology:** Good waterproof performance, all kinds of climate can be used, on the inside wall piece and material formation protection. The material selection of the request is not high. The construction requirement is not high.

In recent years, in Heilongjiang, Inner Mongolia, Gansu Province, such as the north cold area wall sandwich insulation technology has been a certain degree used. But such not cold wall is thicker than traditional wall and external tablet still between the need to have connection with fittings and compared the traditional wall structure is relatively complicated and earthquake resistance is poorer, hot (cold) bridge problems still exist, the performance of the heat preservation material in the external wall thermal insulation technology can give full play to the next.

The waterproofness and weatherability is shown as Fig. 3. The heat insulation, thermal insulation is shown as Fig. 4. The construction conditions of the degree of convenience is shown as Fig. 5.

### CHOICE OF WALL INSULATION MATERIALS

**Selection of thermal insulation material:** At present, the external wall thermal insulation material of our market is polystyrene foam and fast polystyrene foam. Both of these materials are flammable, this means, using both external wall thermal insulation materials, there was a fire hazard. In the building construction process and after the use process, fire is not completely avoided, for example, welding process will produce a large number of sparking. Because of this the fire phenomenon caused by the external wall thermal insulation material is inevitable in fact. According to appeal discussion, we can draw the conclusion that the external wall thermal insulation material cause fire, fire source is external factors. Improve the construction of standardization can reduce the risk of harm; Polystyrene foam and extruded polystyrene foam these two kinds of fuel is the intrinsic factor. In order to prevent fire, using no combustible or flammable materials is the best solution. When choose external wall thermal insulation material, we need to choose A level product which means that no combustible material. But at present, our country market in the external wall thermal insulation material are most of the organic material, even joined the flame retardant, highest can only achieve B1 level. If we want to strictly carry out fire orders, it means China's outer wall heat preservation material will be faced with overhaul, even shuffling or out of position. So, in this period, on the revision of standards of the external wall thermal insulation products rising voice in the industry.

Security environmental protection of external wall thermal insulation material should meet the following three conditions.

Firstly, the production process must be environmental protection, not only can't cause immediate harm to the environment but also can't bury accident hidden danger.

Secondly, the quality and safety of the material itself must keep high standard. In the transport, storage, management and use and waste disposal of hidden links do not occur from the cold spring, also not secondary disasters.

Thirdly, material life cycle energy consumption and material consumptions, to the ecological environment and the effects of climate change, waste discharge and treatment, as well as comprehensive cost to further improve. The experts said, "is not easy to happen" and "not occur" has essential difference, the workers of the letter of the statement that makes the heat preservation material industry saw a slim chance of survival.

How to choose safe and environmental protection of external wall thermal insulation material is the industry's focus on field and determines our country building insulation energy-saving building materials industry's healthy development. Nowadays, the most important problem which we faced is energy crisis. In addition to continuing the development of new energy, as well as the addition to the research and development of recyclable energy, energy conservation is our foremost priority, alleviating energy consumption rate, reducing unnecessary energy use. At present, our country's housing energy loss content roughly: Wall about 50%, housing about 10%, the doors and windows about 25%, the basement and ground about 15%. Thus it can be seen, external wall and roof energy saving problem is the need to pay attention to, effectively improve the outer wall heat preservation efficiency is an important measure. Therefore, the promotion of external wall thermal insulation is very necessary.

**Choice of enhance network:** The glass fiber grid cloth which treated as crack cover key reinforced material in the external wall thermal insulation technology got rapid development. On the one hand, it can effectively increase the tensile strength of the protective layer, on the other hand, because effectively disperse stress will originally can crack spread into more fine cracks, thus creating a crack effect. Also, because of cracking mortar for alkaline, fiberglass mesh cloth is the long-term alkali resistance against has important significance for cracks. Therefore, in the choice of enhancement network, it is suggested to use high alkali grid cloth.

**Selection of protective layer of external wall material:**

Cement mortar with high strength, shrinkage, deformation of flexible enough, direct role in the insulation surface, poor weather, resulting in cracking, also have the potential to cause serious take off. To solve this problem is better to use special anti-crack mortar with reasonable enhance network, but also to add right amount of fiber in the mortar to make cracking mortar pressure ratio is less than 3 fold. If the facing outside is brick, steel mesh surface can also be added to the cement the Kang crack mortar, steel wire mesh pitch to a size suitable for the short side of the brick to cover more than two mesh, wire best anti-corrosion better hot-dip galvanized steel wire.

**EXTERIOR INSULATION TECHNOLOGY PROBLEMS AND SOLUTIONS**

At present, there are some obvious problems in China's external wall thermal insulation technology: First, is there is still serious thermal bridge in some parts of the architecture. Second, the compatibility of the performance of the material in the exterior insulation system is not ideal. Third, EPS board falls off phenomenon. Fourth, insulation wall cracking phenomenon. There are some solutions to resolve these few issues to reference.

**Thermal bridge problem:** Before the construction, we must carefully familiar with drawings, review the node of the insulation design, special attention should be paid to easily neglect position, such as light surrounding, concrete outside carry along, exterior wall rone and other parts.

To seek the owner's opinions before construction, the insulation design views related to the owners added to the design of thermal insulation.

External insulation construction near the exterior wall of the same side, while there may be similar to the construction of the welding gas welding and other professional cross, in this case, you have to wait for these construction after the end of construction.

**Compatibility problem:** Stucco material used for exterior insulation and finish systems, strengthening materials, adhesives, finishes and materials should be compatible with the of moisturizing particles, insulation board insulation materials, thermal insulation system of all material should be using the system suppliers and it undertake the responsibility.

The designer should determine various performance to meet the actual standards in accordance with the relevant standards.

Design units and material suppliers to select and provide appropriate external thermal insulation system with in accordance with the actual needs of the specific project.

Exterior insulation system and various ancillary materials in accordance with the indicators in the pre-construction inspection.

**EPS board off problem:** The design units must do internal condensation moisture experiments for exterior wall, which do not conform should replace timely or take moisture measures.

Select the special putty which has well permeability, good weather resistance and other performance indicators that match with the external wall insulation system.

To calculate the height of the wind pressure of the different layers of wind pressure and the insulation layer fixed value, while the external insulation layer specification resistance to negative wind pressure detection. To ensure the thermal insulation layer was not damaged and lead to fall off.

EPS plate paste, should make plate a seam width less than 2 mm, if more than 2 mm, with EPS batten filling to ensure water vapour in the air proud uniform infiltration (Miao *et al.*, 2013).

To improve the strength of the insulation board as far as possible improves the paste area.

**Insulation wall cracking:** Cracking mortar and fiberglass mesh laid between the two materials to enhance the tensile cracking performance, thereby improving the thermal insulation system of anti-temperature deformation properties.

Often clean base surface, paste polystyrene board, use as far as possible with viscosity method. First the wall will be raised. Hollowing and uncle get hold parts of leveling, the grass-roots level flatness ideal for less than 3 mm. In the back of polystyrene board evenly daub adhesive after the paste in the wall.

Configured the surface mortar according to a certain proportion, anti-cracking mortar bond strength and flexibility of variation and the formation of a surface layer cracking avoid wiping the surface due to the reduction in the proportion of the polymer glue.

## CONCLUSION

The state council development research center in early 2003 organized the "integrated national energy strategy and policy research", it pointed out: China's current building nearly 42 billion square meters, with 99% belong to high energy consumption building materials, in new buildings, more than 95% of them are still high

buildings, the energy consumption per unit area is 3 times of the developed countries.

Decree 76 of the Ministry of Construction released on October 1, 2000 "Energy conservation regulations on projects that do not meet energy efficiency standards and shall not approve construction". For now, to adapt to the requirements of current building energy efficiency, to the spirit of people-oriented, environmental protection, energy conservation spirit route, provide comfortable housing residential environment for the people in the maximum range for building energy conservation and environmental protection is the trend.

At the same time, the exterior insulation technology came into being, the insulation material is about to be placed outside of the main building envelope, so as to achieve the purpose of the insulation. This technology can effectively solve the problem of the energy loss caused by the summer and winter due to the relationship between the indoor and outdoor temperature, this is the new direction of development in energy saving and environmental protection technology in China. External wall insulation does not produce thermal bridge, so it has a good effect on energy efficiency, when the indoor heat in the winter through the wall insulation materials will be isolated and preserved and the wall of the heat released when the indoor temperature drops, the mediation room temperature, in the summer, the external wall insulation also can organize the ultraviolet and external heat introduced into the chamber, so that the building cool in summer and warm in winter, people's living environment more comfortable.

External wall insulation can also play a role to protect the main structure, the external wall insulation material is placed outside of the main structure, reducing the impact of natural conditions outside of the main structure, repeated use in the summer and winter, the body often because cracks caused by thermal expansion and contraction principle, resulting in the shrinking of its useful life. Exterior insulation can reduce this adverse impact. This technology in the transformation of existing homes also make more convenient, because the exterior insulation can focus on transformation, does not affect the normal life of the indoor residents. In addition, compared with the inner insulation technology, exterior insulation technology package material to the outside of the wall, saving interior space and increase the use of the area.

## ACKNOWLEDGMENT

This study is supported by Science and Technology Research Project of Science and Technology Department



in Henan Province (No. 112102210457) and Natural Science Foundation Project of Education Department in Henan Province (No. 2011C580003) of China.

#### REFERENCES

- Bier, H., 2012. Interactive Building. *Adv. Inter. Things*, 2: 86-90.
- Chakraborty, S., P. Kumar and S.K. Chakraborty, 2012. Neural network approach to response of buildings due to earthquake excitation. *Int. J. Geosci.*, 3: 630-639.
- Herrera, R.I., J.C. Vielma, R. Ugel, Y. Martinez and A. Barbat, 2012. Optimal design and earthquake-resistant design evaluation of low-rise framed RC structure. *Nat. Sci.*, 4: 677-685.
- Miao, Q., L. Bian, X. Wang and C. Xu, 2013. Study on building and modeling of virtual data of Xiaosha river artificial wetland. *J. Environ. Protect.*, 4: 48-50.
- Oluwole, O.O., J.S. Joshua and H.O. Nwagwo, 2012. Finite element modeling of low heat conducting building bricks. *J. Miner. Mat. Character Eng.*, 11: 800-806.
- Rahnema, H. and S. Mirasi, 2012. Seismic and geotechnical study of land subsidence and vulnerability of rural buildings. *Int. J. Geosci.*, 3: 878-884.
- Serag-Eldin, M.A., 2013. Design of heat storage for a solar concentrator driving an absorption chiller. *Engineering*, 5: 107-116.
- Suwanbamrung, C., N. Tapalak, C. Jitchun, C. Promsuwan, S. Prosupa, Y. Muenraj and A. Dumpan, 2012. Student capacity building of dengue prevention and control: A study of an Islamic school, Southern Thailand. *Health*, 4: 366-376.
- Thamer, A.D., M.H. Hafiz and B.S. Mahdi, 2012. Mechanism of building-up deposited layer during electro-spark deposition. *J. Surface Eng. Mat. Adv. Technol.*, 2: 258-263.