Executive Summary

Computational Fluid Dynamics Studies on Cost Effective & Energy Efficient Building Design

Sponsored by

ज्ञान-विज्ञान विमुक्तये

University Grants Commission

Under the Scheme of

Major Research Project

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Submitted by

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Annexure – IX

UNIVERSITY GRANTS COMMISSION

BAHADUR SHAH ZAFAR MARG

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PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. TITLE OF THE PROJECT

Computational Fluid Dynamics Studies on Cost Effective & Energy Efficient Building Design

2. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR

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3. NAME AND ADDRESS OF THE INSTITUTION

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4. UGC APPROVAL LETTER NO. AND DATE

F.No.42-890/2013 (SR) Dt.25.03.2013

5. DATE OF IMPLEMENTATION

01.04.2013

6. TENURE OF THE PROJECT

3 Years Extended to 1 Year

7. TOTAL GRANT ALLOCATED

Rs. 5,54,100.00

8. TOTAL GRANT RECEIVED

Rs. 5,33,600.00

9. FINAL EXPENDITURE

10. TITLE OF THE PROJECT

Computational Fluid Dynamics Studies on Cost Effective & Energy Efficient Building Design

11. OBJECTIVES OF THE PROJECT

- ✓ Study the effect of cost effective and energy efficient building materials on the build environment with the help of CFD software.
- ✓ Study and compare the thermal performance of the above wall with the conventional buildings.
- ✓ Compare the simulated results with the model houses

12. WHETHER OBJECTIVES WERE ACHIEVED (GIVE DETAILS)

- ✓ A thermal analysis of Brick wall construction has been carried out using (Autodesk Ecotect Analysis) simulation tool for different climatic conditions in India. The analysis is based on annual temperature distribution and the comfort band is between 18°C and 26°C. The climatic zones were selected based on studies of Bansal et al. The cities selected for analysis are Jaipur (Hot and Dry climate), Chennai (Warm and Humid), Bengaluru (Moderate), New Delhi (Composite) and Shillong (Cold).

- ✓ Computational Fluid Dynamics (CFD) simulation has been carried out in the model house with detailed analysis of flow, temperature and humidity
- ✓ Validation of CFD results with experiment on different type of buildings like Mud Block, Hollow Block and Rat Trap Bond wall.

13. ACHIEVEMENTS FROM THE PROJECT

- ✓ Simulation studies of different building material like Mud Block, Rat Trap Bond, Hollow Block has been carried out. Velocity, Temperature and Humidity Contours has been arrived
- ✓ Experimentation has been carried out with different types of building
- ✓ Validation of CFD and experimentation has been made

14. SUMMARY OF THE FINDINGS (IN 500 WORDS)

In rural residential buildings forced or mechanical ventilation was rarely used. Natural ventilation is being commonly used. Buildings in rural residential sector use many types of materials for construction. Some sustainable building materials especially for walls, burnt brick and mud block were considered for this work, and CFD was used as simulation tool for analysing their thermal comfort capability. Air flow velocity vectors, temperature and humidity contours of the model houses built with with mud block, burnt brick and rat trap bonded burnt brick walls were obtained from the analysis. The actual temperature measurements were also recorded.

The heat transfer into the room through mud block walls was very less compared to the ceiling heat transfer. Ceilings transmit heat into the building which makes the upper volume of the room air hotter than the lower portion. Also due to the ceiling heat relative humidity variations are high near the areas adjacent to the ceiling. Air entry through the door cools the room air and the rate of air exhaust near the windows depends on the incoming flow rate. Volume weighed average temperature increase was by 0.3^0C. It is suggested that the mud blocks are preferable building material, as they prevent maximum heat transfer into the building from surroundings and help to keep the building self cooled. As locally available mud blocks are used for construction, contribution towards sustainable development in the rural building sector is up to an appreciable level.

Outcome of the CFD simulation analysis on the model houses of rural residential type one with burnt brick walls and another with mud block walls and the validation process were concluded as follows.

Though the patterns of temperature distribution inside both the houses are same air temperature was lesser inside the mud block walled house than the brick walled house. The average temperature difference between two cases was around 0.7^0C, when the maximum local temperature difference was 6^0C. The wall temperature in case of brick walls was maximum than the mud block walls.

It is concluded from this study that stabilized mud block walled construction will minimize heat conductivity from the environment in to the interior of houses and make buildings self cooling. Also burnt bricks can also conduct less heat into the building as the temperature difference between two cases was less for the same boundary conditions. Using the sustainable building materials like mud blocks and burnt bricks will help to achieve a considerable level of thermal comfort in rural residences with no extra cost for comfort cooling equipments.

Observations from the CFD simulation studies on the model rural residential buildings one with rat trap bonded burnt brick walls and another with mud block walls and the validation process were concluded as follows.

Temperature distribution patterns inside both the building are same and the air temperature was lesser inside the rat trap bonded brick wall compared to the mud block walled house. The average temperature difference between two cases was around 0.7^0C, when the maximum local temperature difference was 6^0C. The wall temperature in case of rat trap bonded brick walls was maximum than the mud block walls.

It is concluded from this study that rat trap bonded construction technique for walls will minimize heat conductivity from the environment in to the interior of houses and make buildings self cooling. Using the locally available building materials like burnt bricks and the construction techniques like rat trap bonded wall construction, will help to achieve an appreciable level of thermal comfort in rural residences with no extra expenses for conditioning equipments.

Relative humidity variations inside the houses depend on the heat gain from roof and walls. The majority of heat transfer into the houses depends on the material properties of the

building materials mostly the wall and roof. More the heat gain more the variations in relative humidity values. Also the rate and volume of outdoor air flow into the houses will alter relative humidity values. Controlling the door and window openings will result in the variations in relative humidity inside the houses. The wall materials having higher specific heat capacity and higher thermal conductivity will transfer more heat into the houses and hence to control the relative humidity in such cases either natural or mechanical ventilation provisions for fresh air inflow are required. Mud block houses posses more relative humidity fluctuations than rat trap bond brick walled houses. Hence rat trap bond brick wall construction method will provide comfortable humidity levels in rural houses with suitable ventilation arrangements.

15. CONTRIBUTION TO THE SOCIETY (GIVE DETAILS)

Rural residential sector was not given much attention by the planners and designers due to the profit and financial restrictions. But the major population resides in the rural areas. Hence their interests towards comfortable housing design using sustainable and affordable building materials are to be given due importance. With the help of CFD software all the building materials, that are commonly used for rural buildings has been analyzed for their possible contribution in providing comfort to the occupants. These results are validated with experiments.

16. WHETHER ANY PH.D. ENROLLED/PRODUCED OUT OF THE PROJECT

Yes

17. NO. OF PUBLICATIONS OUT OF THE PROJECT

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(PRINCIPAL INVESTIGATOR) (REGISTRAR/PRINCIPAL)