TRANSITION STUDIES IN RURAL BUILDING TYPOLOGIES: A CASE-STUDY

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ABSTRACT

Influences of development and rapid modernization (technology, lifestyle) are increasingly evident in countries such as India and China housing nearly two billion rural population. The built-environment typology of rural settlements in India are undergoing rapid transitions from vernacular passive dwellings which adopt local material and skill to standardised cement based constructions. There are but, intermediate transitions phases which involves a typology involving both traditional and modern materials. A case study of Bommanahalli village near Bangalore, India is presented in this paper where authors examine one such typology adopting random rubble masonry and burnt brick walls with mud-plaster in the interior (traditional materials) and cement plaster in the exterior (modern material) with a gable clay-tiled roof. The results of this study will throw light into how combining traditional and modern construction materials are giving rise to new building typologies and how this combination performs thermally.

Keywords: rural – urban transitions, rural building typology

INTRODUCTION

India's urban areas recorded an absolute increase in population by 1 million in 2001-2011 decade which is for the first time more than its population increase in rural areas [1]. While urban growth rate was +0.3%, rural population growth rate has recorded -5.95% in the last decade [1]. Bangalore, a major city in South India, alone recorded a population growth rate of 46% in the last decade with a population of 11 million in 2011 [1]. Large scale construction activities, have been taking place to accommodate such rapid increase in population and to build infrastructure for the growing economic activities from the IT and allied sectors. Reinforced cement concrete (RCC) based construction is widely used in high rise and mid-rise apartment complexes (high & middle income) and in high density low-rise housing (low income) in Bangalore's residential sectors. The predominantly rural area of Kunigal (in Tumkur District) adjacent to Bangalore (70.5 km from Kunigal), is undergoing transitions in its rural-urban population distribution. Kunigal recorded 12.55% increase in urban population and 6.88 % decrease in rural population in 2011[1, 2]. However, 84.87% of its population still lives in the rural areas of this district. Movement of people between Kunigal and the nearby metropolitan for employment and an urbanising rural population might be influencing its building construction styles. Building typology similar to that of Bangalore's low-rise housing (low income) can be found in new constructions of the rural areas in Kunigal. Such a trend of transition from traditional styles to modern urban style can be seen in the choice of materials in newly built houses as well as in refurbishments, modifications and additions in the houses of this rural area. Therefore, there are houses which are neither entirely traditional, nor entirely modern, but has elements from both. One can see a palette of materials in the houses of these villages which are in intermediate phases of transition towards an urban-like style. A village, Bommanahalli (12° 48' 13.31"N, 76° 58' 55.35"E), of Kunigal is chosen for a case study to understand how the building typologies are in transition here.

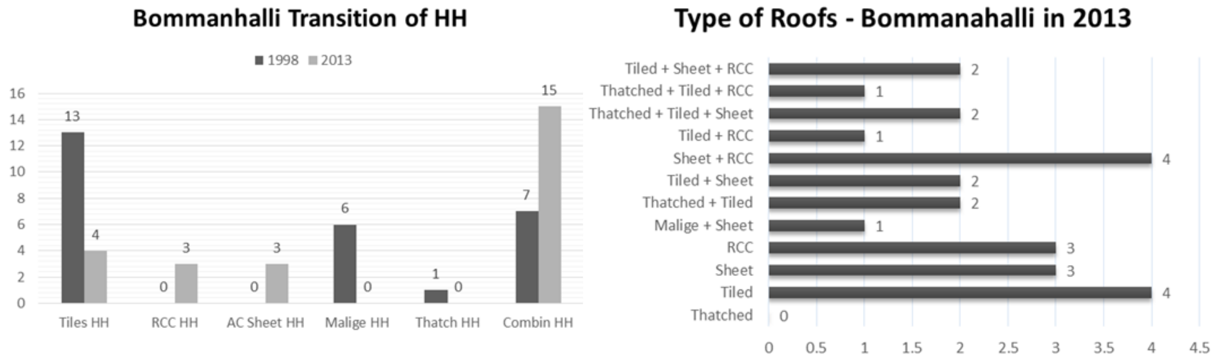

Figure 1: Transition of houses by roof types in Bommanahalli from 1998-2013 (left) and houses by type of roofs in Bommanahalli in 2013 (right).

TRANSITION OF BUILDING TYPOLOGIES

Kunigal has hot and humid climate and temperatures can go up to 40°C in the month of May. Traditional construction practices involve use of locally sourced random rubble masonry and locally made burnt brick masonry for walls, and straw or coconut leaves thatch or Mangalore Tiles for roof. Local masons or people themselves built their houses. From the interviews conducted in Bommanahalli and 2 other adjacent villages, it was learnt that these are no longer practised in new constructions and people prefer modern materials due to their aspirations of having a house similar to those in Bangalore. [2]. New constructions are widely built with cement plastered and painted brick masonry walls, and RCC roofs. This transition is evident when the number of households (HH) by roof types in 1998 and 2013 are compared (Figure 1). Compared to 1998, in 2013, RCC and Sheet (Galvanised Iron/Tin/Asbestos Corrugated roofing sheets) roof types have increased as well as Combination roof types. Combination roof types are those which involve two or more of different roof types in one house. Figure 1 (right) shows the distribution of houses in Bommanahalli by roof types including different combination roofs. The existing traditional constructions which are undergoing additions and partial refurbishments, have combination wall types as well. From the data obtained from Bommanahalli and 2 adjacent villages in Kunigal, it was observed that these transitions seem to follow a trend of direction in terms of the choice of materials for

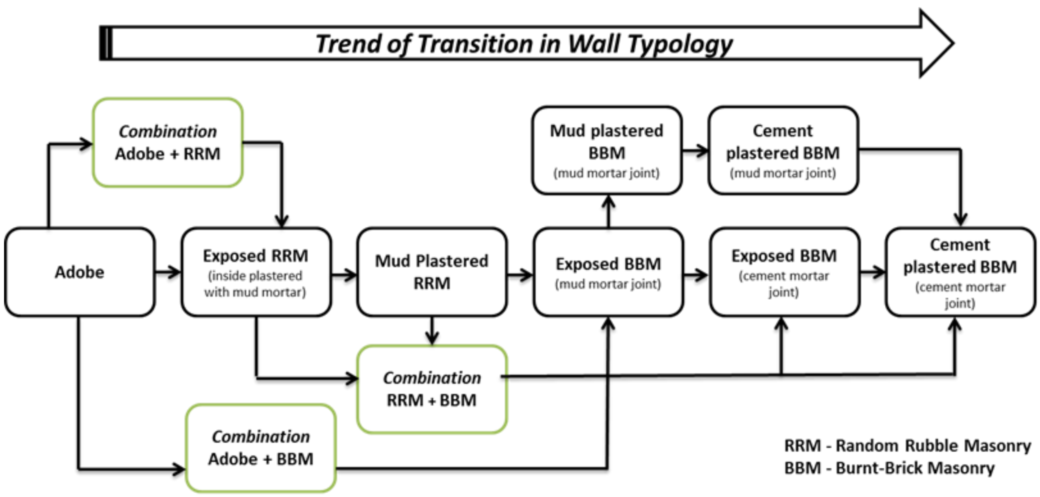

Figure 2: Trend of transition in Wall typology

walls and roofs [2] (see figure 2). One can see in these villages a variety of building typologies with different combination wall and roof types which are at intermediate phases of transition. A house with one such intermediate typology in Bommanahalli is chosen in this study to compare and understand its combination walls and thermal performance in this climate.

CHARACTERISATION OF BUILDING TYPOLOGIES

Since, the existing typologies of Thatched house, Tiled house and RCC house were insufficient to name the kind of typologies which are now prevalent in this village, the authors arrived at a new building typology characterisation based on a matrix of prevalent wall and roof types. The matrix has the change of direction of roof types in columns, and wall types in rows (Figure 3). We then documented all the houses of Bommanahalli based on its wall and roof types in this matrix. The number of houses in each typology are entered in the corresponding cells. This helped in situating the typology of the house the authors chose for further study, by highlighting it with a tick mark in the field. Therefore, the case study house has a combination of tiled and thatched roof, and a combination of Random Rubble Masonry (RRM) and Burnt Brick Masonry (BBM) walls (Figure 4). This matrix will help in classifying and documenting rural houses of other Indian villages as well.

		Roofs													
		Thatched	Tiled	Sheet	RCC	Thatched + Tiled	Thatched+ Sheet	Tiled + Sheet	Tiled + RCC	Sheet + RCC	Thatched + Tiled + Sheet	Thatched + Tiled + RCC	Thatched + Sheet + RCC	Tiled + Sheet + RCC	Thatched + Tiled + Sheet + RCC
Walls	Adobe		2		1	1		1							
	RRM e														
	RRM p							1							
	BBM e														
	BBM p		1	2	3					3			1	3	
	Adobe + RRM e		1												
	Adobe + RRM p									1					
	Adobe + BBM e														
	RRM e +RRM p														
	RRM e + BBM e		1												
	RRM e + BBM p														1
	RRM p + BBM p										1				
	BBM e + BBM p			1				1							
	Adobe + RRM e + BBM e		1												
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Figure 3: Matrix for characterising new building typologies

INFRARED THERMOGRAPHY BASED ANALYSIS

Infrared Thermography (IRT) is used for non-destructive testing of building elements where thermal cameras measure the surface radiation [4, 5]. Passive thermography by walk-through surveys were done capturing both internal and external walls of the case study house. The IRT device used was FLUKE TiR32 IR imaging camera with wide-angle lens from Fluke Thermography (camera characteristics: IR sensor size of 320x240 IR resolution; 76,800 total IR pixels; instrument calibration range -10 °C to 170 °C; software used for post processing is SmartView 3.2.639.0). The advantages of using IRT was that it is portable, and it eliminated the need to leave the device at site without supervision. The residents were apprehensive on installation of temperature data loggers, and such devices were often tampered with or discarded by them soon after installation while not under supervision.

The plan of the house is shown in figure 4 (left) and we measured the indoor and outdoor surface temperatures of each of the walls named in the plan. The images were taken on April 24, 2015 between 12.40 and 13.10 hours (30 minutes) IST (Indian Standard Time) were shadows on walls were minimal. Indoor and outdoor IR image of West wall 1 is shown in

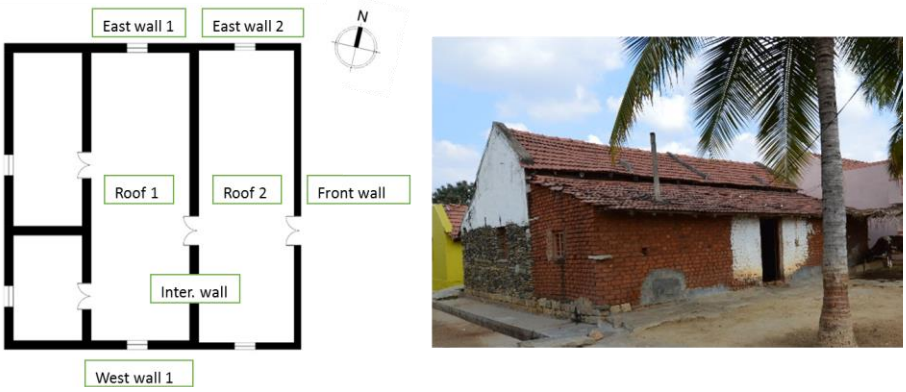

Figure 4: Plan of case study house (left) and image taken at site (right)

figure 5. In this wall, the internal surface temperature was 3.83°C lower than its external surface temperature on the RRM portion. Because IR thermography gives the instantaneous temperature, the indoor-outdoor temperature differences discussed here are not instantaneous measurements, but from the images taken within a 30 minute time span. Similar imaging was done for 7 portions on all external walls with different wall material and surface finish. The results of IR imaging are tabulated in Table 1. Here, exposed BBM has internal surface temperatures which are approximately 4.5°C lower than that of its external surface temperatures. The exposed RRM wall portion in East wall 1 has a much lower internal surface temperature that is 6°C less than that of its external surface temperature, and also it has the lowest internal surface temperature in the East wall 1 and West wall 1 compared to other wall types.

Figure 5: IRT of West wall 1- Indoor surface (top) and outdoor surface (bottom)

Walls	BBM - Exposed			BBM- Plastered & Painted		RRM - Exposed	
	East wall 2	East wall 2a	Front wall	East wall 1	West wall 1	East wall 1	West wall 1
Internal surface temp. (°C)	33.35	33.05	32.12	35.76	35.06	32.2	32.73
External surface temp. (°C)	37.51	37.53	36.86	35.4	33.39	38.85	36.56
Difference in surface temp. (°C)	-4.16	-4.48	-4.74	0.36	1.67	-6.65	-3.83

Table 1: Surface temperatures from IRT

The external surface temperatures of cement plastered and painted BBM portion is the lowest compared to other wall types on East, West and Front walls. However, it has the highest internal surface temperatures compared to all other wall types on all sides. This wall type also has higher internal surface temperatures than its corresponding external surface temperatures.

In the East side, there is a reduction (2°C) in external surface temperature of BBM walls when it is plastered and painted (whitewashed). This is further demonstrated in figure 6 in the thermal image of West Wall 1. Here again, the BBM plastered and painted portion has 3.9°C lesser external surface temperature than the exposed one. The average values of wall surface temperatures for each wall type in West Wall 1 is given in Table 2. In the thermal image of Front wall (Figure 7) in exposed BBM, the painted BBM portion has 2.73°C lower external surface temperatures than the non-painted portion. However, both portions have similar internal surface temperatures.

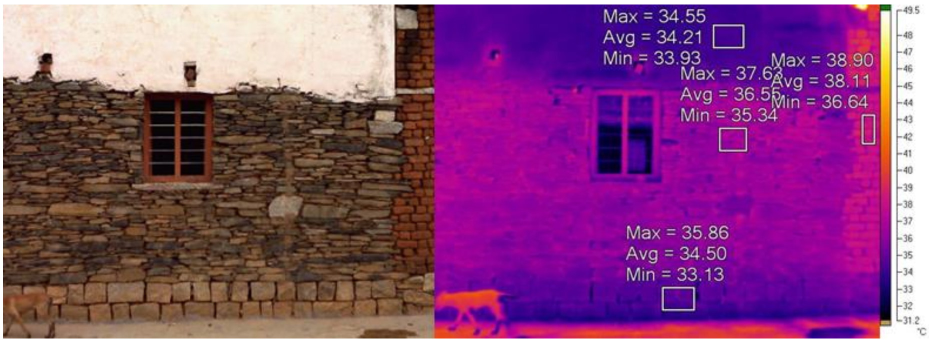

Figure 6: IRT of West wall 1 outdoor surface with 4 different wall types

West Wall	Surface Temperature (°C)
Plastered BBM white-washed	34.21
Exposed BBM in mud mortar	38.11
RRM in mud mortar	36.55
SSM plinth in mud mortar	34.5

Table 2: Surface temperatures from IRT of West Wall 1

Figure 7: IRT of front wall- Indoor surface (top) and outdoor surface (bottom)

DISCUSSIONS

For houses with new building typologies in intermediate transition phases, further study should be done to see how each combination of roofs and walls performs thermally in its climatic condition in order to understand if this trend of transition are in the direction of improved thermal comfort. Shastry et al (2012) in a study done in Sugganahalli (adjacent village of Bommanahalli) showed that traditional buildings have indoor temperatures 7-10°C lower than that of modern RCC houses in the summer months [6]. Cost of construction and non-availability of local masons have been stated as the reasons for adopting new construction practices apart from the aspirations to build modern houses in an interview done in our previous study [3]. Cement plastering and painting seem to be done for the aesthetic aspirations of the people and it does not appear to change indoor wall temperatures from our IRT study. The transition trend also seem to be towards building houses which are more rigid and durable. The transition of building typologies are also found shaping the rural-scape at street-level and village level [2, 3]. For example, reduced interaction with neighbours and street by the prevalence of compound walls in new houses.

CONCLUSIONS

Building construction in rural areas near Bangalore is transitioning from traditional to a more urban style. People combine traditional materials and new materials for construction based on socio-economic reasons (availability of masons and resources), as well as emotional reasons (aspirations). Rapidly transitioning fast paced constructions in this village leaves climatic considerations behind. Standardisation of building design and styles across rural areas of India is a serious concern in a country with varied climatic zones and high rural population. Thermal performance of new building typologies with combination of materials should be studied in depth, so that effective integration of these combinations can help in designing buildings for better thermal performance and comfort. Houses in this intermediate phases of transition are learning grounds for understanding evolution of building designs and for arriving at new typologies of climate friendly designs with available resources.

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