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Research Article

Cost Implications for the Construction of Earthquake Resistant Load Bearing Residential Building

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A B S T R A C T

This study was conducted to analyze the Cost Implication for the Construction of Earthquake Resistant Load Bearing Residential Building with a case of Ramechhap District of Nepal. Analysis has been done by using NRA for design, District rate 072/073 from DDC Ramechhap for cost estimate, NBC Code to show the features of earthquake resistant load bearing building. The cost of these models were ranging from Rs. 4,01,643.36 to 21,21,078.75 for constructing of residential building. Rs. 4,01,643.36 seems to be the lowest cost for SMC-1.2 model and Rs 21,21,078.75 is the highest cost for BMC-2.4 But According to Plinth Area rate, Minimum Cost was taken by SMM 1.1. and it had taken Rs. 8, 52,950.64. The cost difference between earthquake resistant building and convention type building was found to be Rs. 2,10,345.09 which is 16.67% cost more than conventional type building and also the cost of earthquake resistant features is the cost difference between the earthquake resistant building and conventional type building.

Keywords: Cost Variation, Cost Estimation, Earthquake Features, NRA Design

Introduction

Mostly residential building construction practice has been carried out in Nepal in an ad hoc basis using owner builder system without consulting architects and engineers and without considering the earthquake safety measures. Even with the incident of past huge earthquakes and its adverse effects, people have not yet understood the need of earthquake resistant buildings (KC, 2013). The main reason to this might be the lack of awareness and misconception of people. Generally people believe that earthquake resistant building construction is much costly than the buildings build in a conventional way and Furthermore, GON has designed 17 different models of Earthquake Resistant Load Bearing Residential Building for the reconstruction in earthquake affected 14 districtsby donating money for the victim. Comparatively, construction cost is low for the load bearing structure but most of researches are based on RCC frame structure rather than load Bearing Structure. So demand of research on load Bearing Structure in now days and after earthquake 2015 in remote rural areas is high, Government of Nepal is going to construct large number of load bearing building in Village. Therefore today's society demands a study or a research to find out actual cost difference between the earthquake resistant load bearing building and without considering earthquake resistant residential building.

Nepal has developed National Building Code (NBC) and already put in implementation. But still construction of building as per the spirit of the code wasnot happening due to several constraints such as resource lack, lack of effective coordination, poor monitoring and evaluation mechanisms. A number of local bodies are still not following National Building Code (NBC) (Shrestha, et al, 2014).

Therefore, this study has attempted to collect the information on current practices in the residence building construction within the Ramechhap district. The research further compares and analyses the cost of 17 different models of Earthquake Resistant Load Bearing Residential Building based on structural features for Earthquake-Resistant Load-Bearing buildings studied by Mishra and Thing (2019) to showthe detail estimation of building and cost analysis of most accepted building by the local public.

- The overall objective of the research is to find cost of 17 different model building with its features and figure out the cost variation between the earthquake resistant load bearing building and other conventional load bearing residential building in Ramechhap.

Literature Review

Impact of Seismic Resistant RCC Residential Building on Cost in Nepal

KC (2013) deals with the cost difference in percentage between the engineered and the non-engineered residential model building. Current practice of building construction in Nepal is predominated by owners and local contractors. Owners and local contractor have minimum level of technical knowledge regarding earthquake resistant features and it is found that people are still unaware about the effects of earthquake to the buildings. During the earthquake, buildings collapse due to lack of earthquake resistant features, use of inferior construction materials and improper construction technique. There is the misconception among people that earthquake resistant building cost much higher than normal building construction. Due to this reason, people usually ignore the earthquake resistant features in their construction.

The main objective of this research work is to find the cost difference between non-engineered residential building and engineered earthquake resistant residential building of the same model building.

The study was commenced with the reviews of earthquake concept and its effects, earthquake risk of Kathmandu valley, earthquake risk management techniques, Nepal National Building Code and its provisions along with current construction practices of building in Kathmandu Valley. Reviews on cost of buildings and effect of a seismic design on building cost and cost modeling of reinforced concrete buildings designed for seismic effects were also done.

The research was concentrated to collect the information on current practice of residential building construction at Tyanglaphat and Bhatkyapati area of Kirtipur municipality. Twenty five numbers of residential buildings of Tyanglaphat and Bhatkyapati area were considered as cases for study. Questionnaire survey was carried out to collect the information on current practice of residential buildings. Field study generates the model building (as sample building) for the research work, with its architecture features. Structural details as per current non-engineered practice were also developed. Then detail cost estimate was carried out for the generated model building. The same model building was designed (As engineered building) using structural analysis tool SAP 2000 and its structural detail/ drawings were prepared as per Nepal National Building Code.

Detail cost estimate of the designed building was carried out. Then the comparative study and analysis was carried out between engineered and non-engineered model building. It is revealed that the cost difference in percentage between the engineered and the non-engineered residential model building is 12.18%. This difference is only for the structural cost, other cost being same the difference in total cost will be even lower.

The study therefore shows that the cost of engineered building is not much higher compared to non- engineered building. It is also found that the awareness on earthquake resistant features to buildings was very low both in house owner and local contractor. With the increased level of awareness and dissemination of this research finding, it can significantly reduce the misconception of people on the cost of engineered building. In addition to this it is expected to help promoting people towards the construction of earthquake resistant buildings.

Percentage of Cost Composition in Buildings Designed by MRT

Bhattrai and Mishra, 2017, deals three types of cost which jointly determined the total cost of building. Structural cost, non- structural cost and content cost. Structural costs are those costs related to structural components of building. Structural component of building are foundations, columns, beams, slab etc. cement, sand, aggregate, reinforcement were the construction material used in structural component of buildings. Similarly non structural cost comprised of masonry infill, openings etc. Similarly content cost is the cost of electrical, sanitary, furniture and fixtures.

Three buildings under the study were estimated as per prevailing government rate and analysis to determine the structure and non structural cost. Similarly content cost was determined from house owner. On an average 21% of building cost covered by structural component, 45% by non structural and remaining 34% of cost covered by content (Figure 1).

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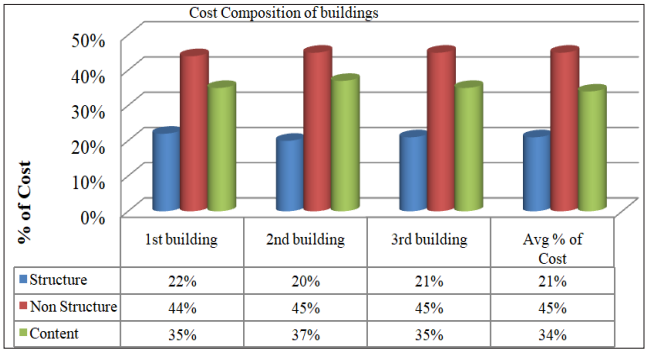

Figure 1.Factors affecting drilling fluid choice

Source: Bhattraai and Mishra, 2017

Earthquake Resistant Load Bearing Residential Building in Nepal

Seventeen different types of proposed designs included in the Design Catalogue for Reconstruction of Rural Housing can be selected and used as is, the prototype designs, or can be adapted based on the parameters as defined in the National Building Code of Nepal, the application process The Design Catalogue for Reconstruction of Rural Housing can also provide guidance in terms of budgeting, and estimating the quantity of material required and as a general guide for basic earthquake resistant construction techniques. The plinth band, sill band, lintel band, vertical core, stitch and gable band were earthquake resistant features based on codal provision in 17 models but in implementation were not found in conventional building in previous day. The earthquake resistant features are plinth band, sill band, lintel band, vertical core, stitch and gable band in load bearing structure including 17 models of NRA provided design which are based on National Building Code (Mishra and Thing, 2019).

Methodology

The data has been evaluated discretely under the headings:

- Features Assessment of Earthquake Resistant Element in 17 different model of load bearing buildingsand differentiatingit with conventional building has been assessed from previous study conducted by Mishra and Thing (2019).
- Cost of different 17 models has been analysed.Best Selected design has been selected for the detail analysis.
- Cost Impact analysis of Earthquake Resistant features for constructing earthquake resistive load bearing buildings.
- Cost difference between earthquake resistance load bearing building and conventional building.

Analysis has been done to show the features of earthquake resistant load bearing building. Analysis was also done to find out the awareness level on National Building Code and use of earthquake resistant features in building among the house-owner and local contractor. Their perception about the additional cost in earthquake resistant building, similarly. Out of 17 models provided by NRA, analysis has been done to find out most beneficiary acceptance model among them.

Table 1.Research Matrix

Objective	Information Required	Data Source	Methodology/ Tools	Output
To find cost of 17 different model of the earthquake resistant loadbearing building in Ramechhap District	17 model design, Contemporary rate of different materials in Ramechhap, Rate Analysis	NRA for design, District rate 072/073 from DDC Ramechhap for cost estimate, NBC Code	Desk Study for Evaluating Cost of all 17 models	Cost Estimate of 17 models
To detect the cost variance between the earthquake resistant load bearing building and other conventional loadbearing residential building in Ramechhap	Cost of sample model & conventional building in Ramechhap	From Desk Study	Evaluation of the Construction Cost of sample models, Conventional Building	Cost Difference between earthquake resistance load bearing building and conventional Building. Percentage of Extra cost required for earth quake resistant Building
To find the cost of Earthquake resistant features in load bearing building in Ramechhap District.	Drawing Details of the features of building, Contemporary rate of different materials in Ramechhap	NRA for design, District rate 072/073 from DDC Ramechhap for cost estimate	Desk Study for Evaluating Cost of the earthquake resistant features of Building	Cost of Earthquake resistant features in load bearing building

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Table 2.Summary of Total Cost of 17 different Models of Earthquake Resistant Load Bearing

Model No.	Skilled	Un skilled	Stone	Brick	Cement	Sand	Aggregate	Local wood	Ply wood	Rebar	CGI Sheet	GI Sheet	Plain sheet	Slate	Area	Total Amount (Rs.)	plinth rate (sqm)
	Md	Md	Cu.m.	Nos	bags	Cu.m.	Cu.m.	Cu.m.	Sq.m.	kg.	bundle	Rm	Rm	Sq.m.	Sq.m.		
SMC-1.1	149	361	34		141	21	9	2.27	10	460	5				31.75	706,580.28	22,254.50
SMC-1.2	70	110	20		90	12	3	1.96	10	323	4				15.88	401,643.36	25,292.40
SMC-2.1	192	256	55		220	36	6	3.77	10	630	5				31.75	894,830.98	28,183.65
SMC-2.2	304	458	72		200	40	10	5.58		1141	4.69	10	10		47.4	1,246,179.84	26,290.71
SMC-2.3	263	592	86		311	48	26	2.94		1792	4.5	11			32.6	1,319,972.97	40,489.97
SMC-2.4	286	565	107.22		253	49	8	5.37		703	4.36	11			43.3	1,326,763.06	30,641.18
SMC-2.5	418	745	138		306	59	11	6.45		878	5.22	32			53.68	1,699,117.61	31,652.71
SMC-2.6	412	962	132		504	81	31	2.09		2814					48.9	1,890,818.20	38,667.04
BMC-1.1	129	183		22099	67	10	2	2.27	10	300	5				31.75	814,619.66	25,657.31
BMC-1.2	60	90		5600	55	15	1.5	1.94	10	285	4				16.31	424,387.50	26,020.08
BMC-2.1	180	240		16800	130	20	3	4.43	10	403	5				31.75	1,012,314.00	31,883.91
BMC-2.2	280	241		37948	183	25	7	5.14		863	5.15	26			51.3	1,564,826.76	30,503.45

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BMC-2.3	267	273		38306	175	27	7	6		763	4.51	9			45.35	1,614,451.70	35,599.82
BMC-2.4	408	345		51559	252	34	11	7		828	4.97	32			50.76	2,121,078.75	41,786.42
BMC-2.5	296	396		41730	302	37	16	1.64		1791					41.22	1,675,660.62	40,651.64
SMM-1.1	238	197	55					7.66						61	47.4	852,950.64	17,994.74
BMM-1.1	163	151		23514	97	17	4	3.87			4.11	10			40.55	954,976.75	23,550.60
Rate (NRs.)	670	535	900	16.02	850.5	1710	1720	63504	403.83	81.06	5244.96	252.17	300.75	855			

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Research Matrix

Research Matrix is shown in Table 1, as a framework of research.

Results and Discussion

Cost of 17 different model building with its features and figure out the cost variation between the earthquake resistant load bearing building and other conventional load bearing residential building in Ramechhap.

Cost of 17 Different Model Building

According to the District rate-2072/073 in Ramechhap, total cost of different 17 models earthquake resistant load bearing residential building has been calculated, which can be manifestly perceived in table 2. From the table 2 it can be demonstrated that Rs. 4,01,643.36 seems to be the lowest cost and 21,21,078.75 is the highest cost for SMC-1.2 & BMC-2.4 respectively for constructing residential building. But According to Plinth Area rate, SMM 1.1 governs the minimum cost.

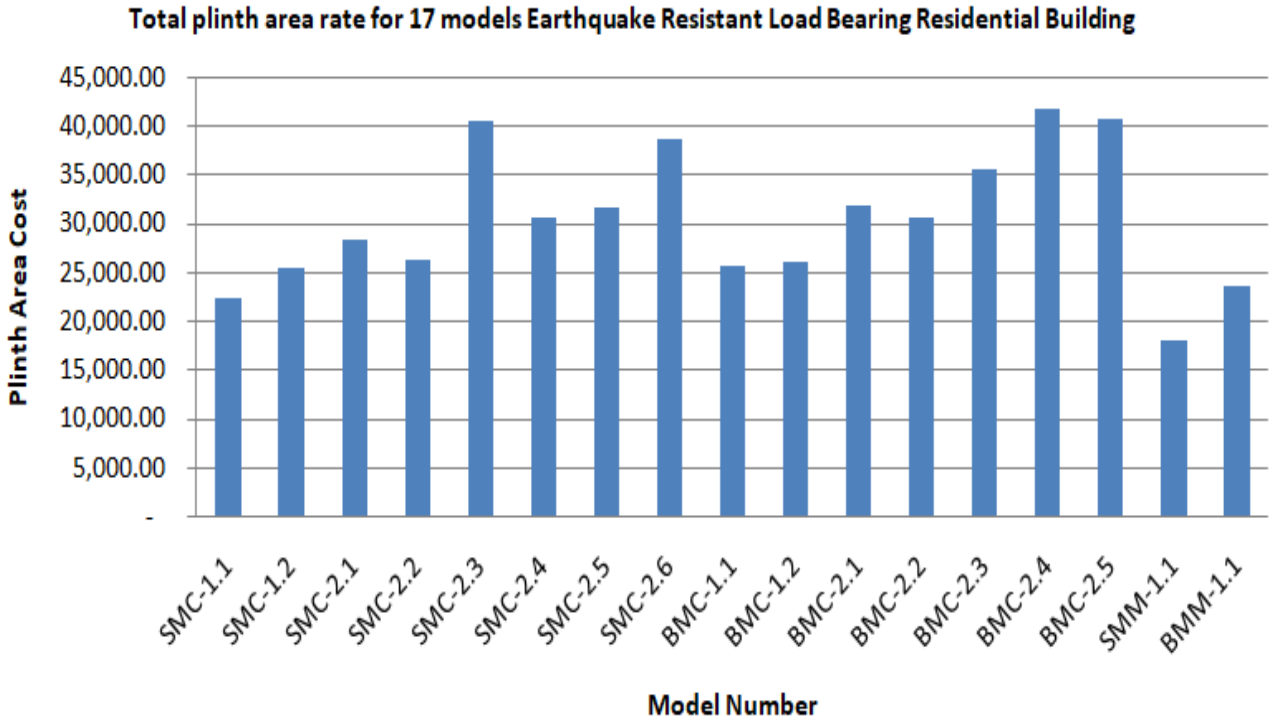

Figure 2.Summary of Total Plinth Area Cost for 17 Models Earthquake Resistant Load Bearing Residential Building

Cost Comparison the Earthquake Resistant & Conventional Type Loadbearing Building

- **Cost of SMM-1.1: Stone Masonry In Mud Mortar:**

Interesting fact about model SMM-1.1 is that all the required engineering materials are available locally. This Model is taken in consideration for detail cost estimation due to high acceptance of majority people in Nepal. From table 4.4 it can be evidently seen that for building proposed model, it is costing about total Rs. 8,52,950.64. Furthermore, GON has considered that all the obligatory materials is locally available, hence if materials cost is excluded and house owner provided some work effort than it can be built within the relief money Rs. 200,000 donated through GON. Not only that, 80% of the materials from the demolished building due to earthquake can be used for the construction.

- **Cost of Conventional Type Based on SMM-1.1: Stone Masonry In Mud Mortar:**

This model is based on SMM-1.1 because all the required quantity for constructing is same besides the plinth band, sill lintel band. The materials for the elements were local wood. The cost difference between these two models was the cost of plinth band, sill lintel band. From table 5. it can be evidently seen that for building proposed model, it was the costing about total Rs. 6,64,343.76. This was numerically 22.11% lower than that of the cost of earthquake resistant model SMM1.1. Furthermore, During FGD and KII the wooden material is locally available at Nrs 1200/-per cubic feet which means Nrs 42,336/- per cubic meter cost. But for the estimation purpose approved district rate was taken in consideration. So cost difference between Conventional building and earthquake resistant building assuming wood available in least cost was near about 16.46% of the total cost of the building.

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Table 3.Summary of Cost Estimate for Earthquake Resistant Building in Model SMM-1.1

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
A.	**Up to DPC**				
1.	Earthwork Excavation for foundation	Cu.m.	21.51	506.96	10,904.71
2.	Earth filling work	Cu.m.	14	309.35	4,330.90
3.	Stone Masonry Work	Cu.m.	22.9	4628.07	105,982.80
4.	Wooden work for DPC	Cu.m.	0.37	73,029.60	27,020.95
B.	**Floor finishing work**				0.00
1.	Stone soling	Cu.m.	2.81	2,164.87	6,083.28
	Sub Total Cost A				**154,322.65**
C.	**Above DPC**				
1.	Stone work for superstructure	Cu.m.	29.3	4628.07	135,602.45
2.	FRAME for wood	Cu.m.	0.1	110973.19	11,097.32
3.	Sill lintel ,Band for wood	Cu.m.	2.6	73,029.60	189,876.96
4.	Flush door shutter	Sq.m.	6.57	5,097.67	33,491.69
5.	Glazed shutter	Sq.m.	3.43	5,594.79	19,190.13
6.	Wooden work for floor	Cu.m.	2.58805	73,029.60	189,004.23
D.	**Roofing works**				0.00
1.	Slate supplying and Laying	Sq.m.	47.40	2359.80	111,854.52
2.	Wood work for Rafter, Horizontal & Vertical members and others	Cu.m.	1.8	73,029.60	131,453.28
E.	**Miscellneous Work**				0.00
1.	Mud plaster,mud flooring etc	Job	1	5,000.00	5,000.00
	Sub Total Cost B				**826,570.59**
	Total Cost A+B				**980,893.24**
	Without 15% of Cont's overhead				**852,950.64**

Table 4.Summary of Cost Estimate for Earthquake Resistant Building in Model SMM-1.1

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
A.	**Up to DPC**				
1.	Earthwork Excavation for foundation	Cu.m.	21.51	506.96	10,904.71
2.	Earth filling work	Cu.m.	14	309.35	4,330.90
3.	Stone Masonry Work in foundation up to plinth in mud Mortar.	Cu.m.	22.9	4628.07	105,982.80
B.	**Floor finishing work**				0.00
1.	Stone soling	Cu.m.	2.81	2,164.87	6,083.28
	Sub Total Cost A				**127,301.70**
C.	**Above DPC**				
1.	Stone work for superstructure in mud mortar	Cu.m.	29.3	4628.07	135,602.45
2.	FRAME for wood	Cu.m.	0.1	110973.19	11,097.32
3.	Flush door shutter	Sq.m.	6.57	5,097.67	33,491.69
4.	Glazed shutter	Sq.m.	3.43	5,594.79	19,190.13
5.	Wooden work for floor	Cu.m.	2.5880497	73,029.60	189,004.23

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D.	**Roofing works**				0.00
1.	Slate supplying and Laying	Sq.m.	47.40	2359.80	111,854.52
2.	Wood work for Rafter, Horizontal & Vertical members and others	Cu.m.	1.80	73,029.60	131,453.28
E.	**Miscellneous Work**		-		0.00
1.	Mud plaster,mud flooring etc	job	1.00	5,000.00	5,000.00
	Sub Total Cost B				**636,693.63**
	Total Cost A+B				**763,995.32**
	With out 15% of Cont's overhead				**664,343.76**

- **Cost of SMC-2.2: Stone Masonry In Cement Mortar:**

Since SMM-1.1 is not helping for the large family due to its number of storied and area, hence SMC-2.2 is considered for detail cost analysis. From table 4.6 it can be evidently seen that for constructing proposed model, it is costing about total Rs. 12,46,179.84. Where as, from table 6 it can also be illustrated that up to DPC it is only costing 27.6% of the total cost and rest of the cost is for above DPC. Comparatively wood cost and its working cost seems more in percentage than other materials. But government is providing 90% discount in wood for the earthquake victim hence it can lower the cost to the reasonable level. For that case only RCC can be termed as the major cost determining factor in the total cost. As far the concern of the GON, additional up to 1.5 million rupees can be taken loan in cheap rate for the victim. In that case one can construct SMC-2.2 in their best architect way.

Table 5.Summary of Cost Estimate for Earthquake Resistant Building SMC-2.2: Stone Masonry in Cement Mortar

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
A.	**Up to DPC**				
1.	Earthwork Excavation for foundation	Cu.m.	30.61	506.96	15,518.05
2.	Earth filling work	Cu.m.	14.92	309.35	4,615.50
3.	Stone Masonry Work in Cement mortar in 1:6	Cu.m.	23.15	8,392.42	194,284.52
4.	RCC 1:2:4 work	Cu.m.	1.84	12,923.57	23,779.37
5.	Reinforcement bar	Mt.	0.20	115,797.06	23,159.41
6.	Form work	Sq.m	6.41	833.83	5,344.85
B.	**floor finishing work**				0.00
1.	Sand filling	Cu.m.	1.42	2,398.32	3,402.40
2.	Stone solling	Cu.m.	4.82	2,164.87	10,434.67
3.	500 gauge ordinary Plastic Sheet Laying work	Sq.m.	35.13	121.37	4,263.73
4.	PCC 1:3:6 work	Cu.m.	2.41	10,178.88	24,531.10
5.	3mm cement punning 1:1 c/m	Sq.m.	35.13	242.64	8,523.94
	Sub Total Cost A				**317,857.55**
C.	**Above DPC**				
1.	Stone work for superstructure in cement mortar (1:6)	Cu.m.	37.41	8,392.42	313,960.43
2.	FRAME for door(wooden)	Cu.m.	0.74	110,973.19	82,120.16
3.	flush door shutter	Sq.m.	13.14	5,097.67	66,983.38
4.	Glazed shutter	Sq.m.	6.87	5,594.79	38,436.21
5.	Wooden work for floor	Cu.m.	1.92	91,432.24	175,549.90
6.	RCC M15 SILL/ LINTEL Bands	Cu.m.	5.08	12,923.57	65,651.74
7.	Rod (Steel)	Mt	0.83	115,797.06	96,111.56

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8.	Form work	Sq.m	33.40	833.83	27,849.92
D.	Roofing works				
1.	0.41 mm thick C.G.I. sheet cover	Sq.m.	62.75	966.47	60,645.99
2.	0.50 mm thick C.G.I. plane sheet ridge cover	Rm	8.6	761.75	6,551.05
3.	GI plain sheet partition attic portion	Sq.m.	8.2	1,269.59	10,410.64
4.	Wood work for Rafter, Horizontal & Vertical members	Cu.m.	1.87	91,432.24	170,978.29
	Sub Total Cost B				**1,115,249.27**
	Total Cost A+B				**1,433,106.82**
	Without 15% of Cont's overhead				**1,246,179.84**

- **Cost of Conventional Building (SMC2.2 based design) Stone Masonry In Cement Mortar**

From table 7, for constructing conventional building SMC (STONE MASONRY IN CEMENT MORTAR), 2 storied building in 510 square feet it is costing around Rs. 10,35,834.76. In conventional building also overall comparative cost of wood is decidedly more than other material cost. Correspondingly, if wood is accessible locally then one can save more than 40% in building constructing cost.

Table 6.Summary of Total Cost Estimate for Conventional Building (SMC)

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
A.	**Up to DPC**				
1.	Earthwork Excavation for foundation	Cu.m.	30.61	506.96	15,518.05
2.	Earth filling work	Cu.m.	14.92	309.35	4,615.50
3.	Stone Masonry in Cement mortar in 1:6	Cu.m.	23.15	8,392.42	194,284.52
4.	Sand filling	Cu.m.	1.42	2,398.32	3,402.40
5.	Stone solling	Cu.m.	4.82	2,164.87	10,434.67
6.	500 gauge ordinary Plastic Sheet Laying work on the ground	Sq.m.	35.13	121.37	4,263.73
7.	PCC 1:3:6 work	Cu.m.	2.41	10,178.88	24,531.10
8.	3mm cement punning 1:1 c/m	Sq.m.	35.13	242.64	8,523.94
C.	**Above DPC**		0.00	-	
1.	Stone work in cement mortar (1:6)	Cu.m.	37.41	8,392.42	313,960.43
2.	FRAME for door(wooden)	Cu.m.	0.74	110,973.19	82,120.16
3.	flush door shutter	Sq.m.	13.14	5,097.67	66,983.38
4.	Glazed shutter	Sq.m.	6.87	5,594.79	38,436.21
5.	Wooden work for floor	Cu.m.	1.92	91,432.24	175,549.90
D.	**Roofing works**		0.00	-	
1.	0.41 mm thick C.G.I. sheet cover	Sq.m.	62.75	966.47	60,645.99
2.	0.50 mm thick C.G.I. plane sheet ridge cover	Rm	8.60	761.75	6,551.05
3.	GI plain sheet partition attic portion	Sq.m.	8.20	1,269.59	10,410.64
4.	Wood work for Rafter, Horizontal & Vertical members and others	Cu.m.	1.87	91,432.24	170,978.29
	Sub Total Cost B				**925,636.05**
	Without 15% of Cont's overhead				**1,035,834.76**
	Plinth Area Rate				**21,853.05**
	Difference with SMC 2.2				**-16.88 %**

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Hence construction cost difference between the conventional model and earthquake resistive building is 16.88%. Furthermore in conventional load bearing building RCC is not used hence for earthquake resistive building comparatively cost difference is high. Comparatively transportation cost will be high for transporting Reinforcement, Cement and Sand to the site of under construction of load bearing structure due to lack of proper access. Hence, cost difference will be more high depending upon the distance of site from headquarter or the presence of proper access.

- **Summary of Cost comparison between earthquake resistant load bearing residential building and conventional building**

Comparison between earthquake resistive and conventional building was done considering structural components and the items which have got implication on cost due to structure of the building. Other items of the building like stonework for super-structure, doors and windows, plaster, painting, floor finishing, kitchen and toilet, electrical and sanitary items were considered same in terms of quantity and cost for both types of building.

The paper of Thiruvengadam, et al. (2004) demonstrate that for an eight storey building located in seismic zone V, a percentage increase of 69% in steel reinforcement is observed compared to non-seismic design. Whereas, the cost premium for incorporating earthquake resistance as a percentage of the structural cost of the building varies from 2 to 30% depending upon the number of storey and seismic zones. But in the case of these 17 load bearing building all the concrete work and reinforcement work is 100% additive cost, since, in conventional building these two engineering materials were not used.

Quantity Variance

Quantities of earthwork in excavation, soling, PCC, stonework in substructure and backfilling of soil is almost same of conventional building. Since RCC, Reinforcement bar and form work is not used in conventional building. Hence 100% of reinforcement steel work, formwork and concrete work are additive quantity in models. From table 4.7 list of quantity can be illustrated with its variance.

Cost Variance

Quantities of earthwork in excavation, soling, PCC, stonework in substructure and backfilling of soil is almost same of conventional building. Since RCC, Reinforcement bar and form work is not used in conventional building. Hence comparative to conventional building it is 100% additive costs for the modeled building in each material. But overall cost increases by 16.88% in mode SMC-2.2 building.

Analysis of Quantity Variance in Major Items

From the cost comparison of two buildings, it is known that among the 17 items, concrete works, reinforcement works and formworks has got considerable cost variance. Hence, quantity variance of these three items was analyzed in detail.

- **Concrete works**

Concrete works is one of the imperative earthquake resistant elements in the building. So, do the total cost of concrete works is moderately higher than other materials. From the table 8, it can be explained that overall cost for Concrete works is Rs. 77,766.18. That is 7.24% of the total cost. Since it is used in band, for supporting horizontal and vertical reinforcement it cannot be derelict or abridged during construction.

- **Reinforcement works**

Reinforcement works is the furthermost significant earthquake resistant element in the building. So, do the total cost of reinforcement works is comparatively higher than former materials. From the table 9 it can be exemplified that total cost for reinforcement is Rs. 103,713.54. That is 8.32% of the total cost. Since it is used as band, horizontal and vertical reinforcement it cannot be neglected or reduced during construction.

Table 7.Summary of Quantity and Cost Difference in RCC for SMC

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Upto DPC				
1.	RCC 1:2:4 work	Cu.m.	1.84	12923.57	23,779.37
	Sub Total Cost				**23,779.37**
	Above DPC				
1.	RCC M15 SILL/LINTEL Bands	Cu.m.	5.08	12923.57	65,651.74
	Sub Total Cost				**65,651.74**
	Total Cost				**89,431.10**
	Without 15% of Cont.'s overhead				**77,766.18**

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Table 8.Summary of Quantity and Cost Difference in Rod (Steel) For SMC

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Upto DPC				
2.	reinforcement bar	Mt.	0.20	115797.06	23,159.41
	Sub Total Cost				**23,159.41**
	Above DPC				
2.	Rod (Steel)	Mt	0.83	115,797.06	96,111.56
	Sub Total Cost				**96,111.56**
					119,270.97
	Without 15% of Cont.'s overhead				**103,713.89**

- **Formworks**

Formwork is also one of the important earthquake resistant elements in the building. So, do the total cost of reinforcement works is relatively higher than other materials. From the table 4.10 it can be illustrated that total cost for formwork is Rs. 36,115.72. That is 2.90% of the total cost. Since it is used during the band, horizontal and vertical reinforcement it cannot be neglected or reduced during construction.

Table 9.Summary of Quantity and Cost Difference in Rod (Steel) For SMC

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Up to DPC				
1.	Form work	Cu.m.	6.41	833.83	5,344.85
	Sub Total Cost				**5,344.85**
	Above DPC				
1.	Form work	Sq.m	43.40	833.83	36,188.22
	Sub Total Cost				**36,188.22**
					41,533.07
	Without 15% of Cont.'s overhead				**36,115.72**

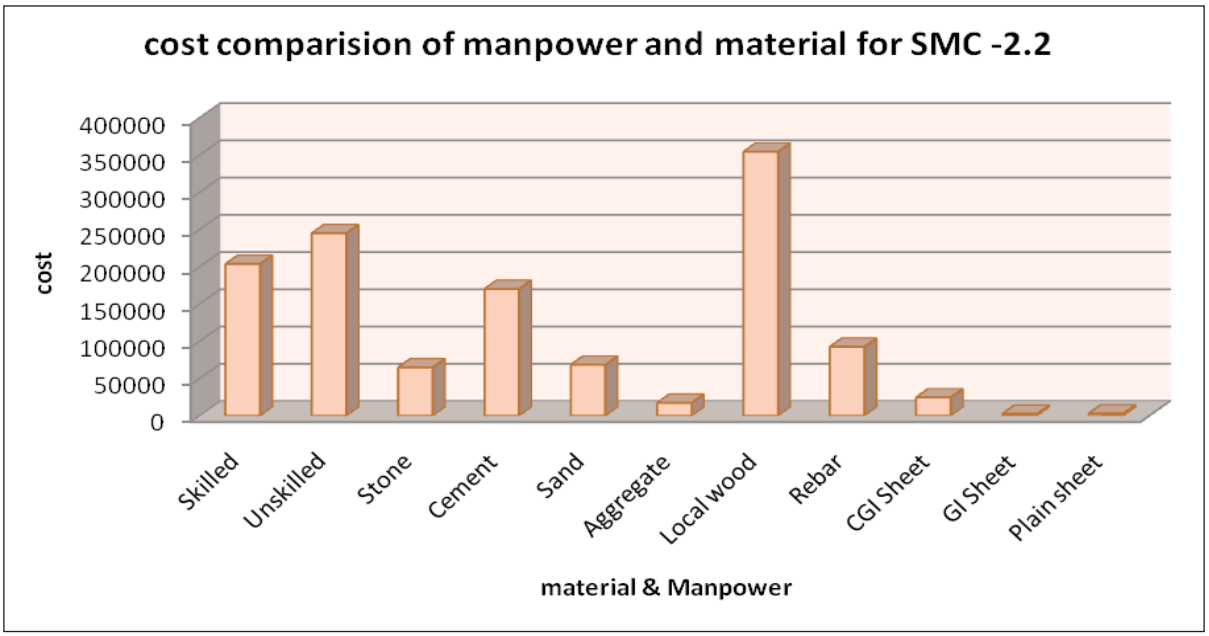

Figure 3.Cost Comparison of Different Manpower's and Materials for Model SMC-2.2

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Cost Showing the different Items in Building

From the figure 3, comparatively local wood cost is higher than the other material and manpower, i.e. 28.96% of the total cost. Furthermore it can be illustrated that concrete cost is not that high as the perception of local people. Hence, if local wood is available, total cost can be dramatically reduced.

Cost of Earthquake Resistant Features in load Bearing Building in Ramechhap District

- **Cost of Earthquake resistant features in load bearing building based on SMC 2.2**

Hence, RCC, Rod (Still) and Formwork are taken as major engineering materials that are categorically making SMC-2.2 as an earthquake resistive building. The formwork was not features of earthquake resisitant features but it was the supporting factor to make the earth resistant element.In Model SMC 2.2 indicating all the model, mainly RCC Band (plinth, sill, Lintel, Stitch, Gable band), vertical core at junction were element of earthquake resistant and the cost of these element was found Nrs 2,10,345.09 which means 16.88% of the total cost of the building. Furthermore it was also the cost difference between Conventional Building and earthquake resistant load bearing building.

- **Cost of Earthquake resistant features in load bearing building based on SMM 1.1**

The cost of Earthquake reisitantfeatures on model SMM 1.1 was found to be Nrs 1,88,606.88. the required quantity for constructing earthquake elements were for the construction of plinth band, sill lintel band stitch, verticalcore. The material for the such elements were local wood. Numerically 22.11% was found for the cost of Earthquake features. Furthermore, During FGD and KII the wooden material is locally available at least cost at the rate of Nrs 1200/-per cubic feet That means Nrs 42,336/- per cubic meter and the cost of the earthquake features in village was found Nrs 109337.32 (With out 15% of Cont's overhead) which cost 16.46% of the total cost of the building

From these 2 selected sample model the cost of the earthquake resistant features was found 16.88% and 16.46% in SMC 2.2 & SMM 1.1 respectively. In Overall the cost of the earthquake resistant features was found 16.67% of the total cost of the building.

Table 10.Summary of Quantity and Cost Difference in Rod (Steel) For SMC

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
	Up to DPC				
1.	RCC 1: 2: 4 work	Cu.m.	1.84	12,923.57	23,779.37
2.	Reinforcement bar	Mt.	0.20	115,797.06	23,159.41
3.	Form work	Cu.m.	6.41	833.83	5,344.85
	Sub Total Cost				**52,283.63**
	Above DPC				
1.	RCC M15 SILL/ LINTEL Bands	Cu.m.	5.08	12,923.57	65,651.74
2.	Rod (Steel)	Mt	0.83	115,797.06	96,111.56
3.	Form work	sqm	33.40	833.83	27,849.92
	Sub Total Cost				**189,613.22**
					241,896.85
	Without 15% of Cont.'s overhead				**210,345.09**

Table 11.Cost of Earthquake resistant features in load bearing building based on SMM 1.1

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.)
1.	Wooden work for DPC	Cu.m.	0.37	73,029.60	27,020.95
	Sub Total Cost A				**27,020.95**
C.	**Above DPC**				
2.	Sill lintel ,Band for wood	Cu.m.	2.6	73,029.60	189,876.96
	Sub Total Cost B				**189,876.96**
	Total Cost A+B				**216,897.91**
	With out 15% of Cont's overhead				**188,606.88**

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Findings

The cost of 17 model buildind are Nrs 706,580.28, 401,643.36, 894,830.98, 1,246,179.84, 1,319,972.97, 1,326,763.06, 1,699,117.61, 1,890,818.20, 814,619.66, 424,387.50, 1,012,314.00, 1,564,826.76, 1,614,451.70, 2,121,078.75, 1,675,660.62, 852,950.64 and 954,976.75 for SMC-1.1, SMC-1.2, SMC-2.1, SMC-2.2, SMC-2.3, SMC-2.4, SMC-2.5, SMC-2.6, BMC-1.1, BMC-1.2, BMC-2.1, BMC-2.2, BMC-2.3, BMC-2.4, BMC-2.5, SMM-1.1 and BMM-1.1 respectively.

From the data it seems Rs.4,01,643.36 seems to be the lowest cost for SMC-1.2 model and Rs 21,21,078.75 is the highest cost for BMC-2.4 But According to Plinth Area rate, Minimum Cost was taken by SMM 1.1. and it had taken Rs. 8, 52,950.64. This study also shows that the total cost of earthquake resistant model building was 16.67% higher than that of cost of conventional building in which the earthquake resistant model building the cost of concrete covers 7.24%, cost of Rebar covers 8.32.%, Cost of form work Cover 2.90% to make the model as a earthquake resistant building.

Conclusion

The cost of 17 models are ranging from Rs.4,01,643.36 to 21,21,078.75 for constructing of residential building. Rs. 4,01,643.36 seems to be the lowest cost for SMC-1.2 model and Rs 21,21,078.75 is the highest cost for BMC-2.4 But According to Plinth Area rate, Minimum Cost was taken by SMM 1.1. and it had taken Rs. 8, 52,950.64.

The cost difference between earthquake resistant building and convention type building was found to be Rs. 2,10,345.09 which is 16.67% cost more than conventional type building. But the expected cost of damage due to expected earthquakes that may occur during the life-time of residential buildings are higher than the additional cost of a seismic design which means that the earthquake resistant design of buildings in Nepal is profitable.

The Main difference between earthquake resistant building and convention type normal load bearing is earthquake resistant features. The research concluded that most of the conventional building do not have the earthquake resistant features and the cost of the features is the cost difference between the earthquake resistant building and conventional type Building which takes Nrs 2,10,345.09 in cost.

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