A PROJECT REPORT
ON

"SCENARIO OF EARTHQUAKE AND SEISMIC HAZZARD ASSESSMENT OF KANGRA REGION"

Submitted in partial fulfillment of the
Requirements for the award of degree
Of
MASTER OF TECHNOLOGY
In
EARTHQUAKE ENGINEERING
(With specialization in Structural Dynamics)

Submitted By
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MAY 2018

CANDIDATE’S DECLARATION

I hereby declare that the work which is being presented in this project entitled, “**SCENARIO OF EARTHQUAKE AND SIESMIC HAZARD ASSESSMENT OF KANGRA REGION** ”, in the partial fulfillment of the requirements for the award of the degree of **Master of Technology** in Earthquake Engineering, with specialization in **Structural Dynamics**, submitted in the Department of Earthquake Engineering, Indian Institute of Technology ROORKEE, is an authentic record of my own work carried out under the supervision of **Dr. JOSODHIR DAS** Associate Professor, Department of Earthquake Engineering, Indian Institute of Technology ROORKEE.

Date: MAY 2018 VISHWAJEET J. BUDRUKE

Place: ROORKEE

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of

Our knowledge and belief.

Date. MAY 2018
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My sincere thanks to all the Professors of Department of Earthquake Engineering. Whose valuable class discussions and support enabled me for understanding the fundamentals of Earthquake Engineering

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ABSTRACT

This report contains the estimation of the ground motion in terms of peak ground acceleration for the Kangra earthquake of 1905. The estimation of PGA is done by two methods for the same earthquake primarily by D.S.H.A. (Deterministic seismic hazard analysis) using ground motion prediction(GMPE) equations by ArcGIS move toward to obtained the PGA values to attain seismic hazard assessment and secondly using intensity empirical relation to obtain seismic hazard assessment by estimating the PGA value and then at last using NGA method to obtain the PGA values and the compare the methods to drawn the best performing approach for ground motion observation. There are some attenuation relationships used to get floor action like Jain et al.(2000), Fukushima & Tanaka(1993) and Akkar and Boomer(2007).

Intensity based relation is being taken. In this file GMPE relationship used is Jain et al. (2000). This relationship is pretty appropriate for Himalayan earthquakes and north west Indian earthquakes. In this work a rectangular vicinity of 2°24’*1°36’ is viewed to be taken of Kangra area and shaped a framework of several grids .A series of factors had been given at everynode of that grid. The formation of grid is carried out with the ArcGIS 10 software. The statistics for PGA is accumulated at each points like distance Rjb from fault line to each node or point ,latitudes longitude and soil type etc. The figure are generated the use of this facts which are displaying ground motions of that area. The calculated ground action then
Compared to recorded most peak floor acclearation this Earthquake. The most important objectives of this thesis to learn about to estimate high ground acceleration using GIS approach in kangra region and perfect scenario of ground motion in soil type and rock type of site.

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Chapter 1. INTRODUCTION

1.1 GENERAL

The state of Himachal Pradesh is positioned in the northern India whose coordinates lies between 30.3°-33.00N latitude and 75.6°-79.00E longitude in the western Himalayas region. From seismic point of view it is situated in the place of terrific Alpine-Himalayan seismic belt which is extending from Alps mountains up to Bhutan-myanmar. Topography of the place is hilly all throughthe state, Shivaliks mountain ranges are located in the south while bounded with the aid of excessive snow blanketed Pir Panjals vary in the north. This State has been hit with the aid of massive numbers of earthquakes happening in this region along with occurring in the neighbouring areas of Jammu and Kashmir in the north, Tibet and Nepal in the east and Uttrakhand Hills in the South-East.

There are range of negative earthquakes going on in the H.P. territory in the course of this centuy for which records is nicely recorded. However Information about ancient Earthquake occurring before famous Kangra 1905 is no longer available. However there is a profile of the seismic hazard in the state, the sorts of present construction, their vulnerability to the earthquake dangers and the ensuing seismic risk from hypothetical earthquake of Magnitude 8 on Richter scale.The seismic Hazzard assessment helps us to describe fault rupture, ground shaking, liquefaction. The Indian Himalayan region is one of the most earthquake prone areas of the world and The strong ground motion is estimated by tacking into account the available database on seismicity, techtonics, geology and attenuation characteristics of the rigion. The estimated ground motion provides the information related the servicity of ground shaking that could be experienced at a location or a region during future earthquake (Gupta,2002) In the existing learn about we are the usage of Deterministic seismic hazard analysis of “Kangra Earthquake 1905” based totally on Arc GIS approach.

1.2 Kangra Region

On April 4, 1905 Kangra earthquake in Himachal Pradesh killed 18,815 people, resulting in large injury to public property, and produced numerous land shape changes. This Kangra earthquake was felt over a massive place covering approximately 300 km from Kangra to Dehradun. The 1905 Kangra earthquake has affected two exclusive areas: one strolling eastward from Kangra to Mandi and Kulu, and 2nd close to Dehradun..The Kangra region felt a maximum depth of X , while the Dehradun location had a maximum depth of VIII. The epicenter of the Kangra earthquake was located at 32.5°N and 76.6°E and this earthquake had a shallow focus. The magnitude of this earthquake used to be estimated around 8.6 and the intensity was once assigned as X in the epicentral region. This epicenter used to be located in the north of the current tectonically active faults, MBT(Main Boundary Thrust) and MFT, in the area of Chamba a nearby town.

This earthquake has resulted in complete casualities of around 20,000 lives & resulted in a most (MMI) depth of X and more , in the epicentral place and over an giant place of 416000 sq.km. It was once concluded by way of the researchers & scientist that this earthquake used to be produced as a end result of displacement taking region alongside a low perspective fault at a depth sixty four km below the earth crust in the MBT fault.As Kangra region lies in zone V, and this is highly severe to earthquake as stated in Indian standard code of practice for earthquake resistant design of structures in the country (IS-1893: 2002). Due to increase in population the necessity of proper earthquake resistant structures becomes highly resistant. As the lack of strong ground recordings is available we need to estimate the strong ground motion for Kangra region in the present study.

Table 1: showing diferent salient features of the Kangra earthquake

Earthquake	Parameters	
Region	Kangra (Himanchal Pradesh)	
Date	04 April 1905	
M_w	8.0	
Depth	15 km	
Epicenter	Kangra, HP	
	Latitude	31’33’00” N
	Longitude	76’52’48” E
Fault	Main Boundary Thrust (MBT)	
Source	Line Source	
Rupture Length	200 km	
Maximum MSK Intensity	9.53 (between IX and X)	

1.3 The main objectives of this study are:

1. The primary targets of this project is to recognize the extent of all the affected areas due to earthquake. Also perceptions the importance of various fundamentals elements length of the fault rupture, distance of epicentre from the region underneathconsideration and the extent & magnitude of ground shaking.
2. To construct two high intensities om MMI scale covering the study area from the evaluation of macroseismic data of Kangra earthquake of 1905.
3. To estimate the strong ground ground motion in the region around kangra by taking into account the effects of various siesmotectonic sources mapped in the study area.
4. To estimate the strong ground motion produced by Kangra Earthquake of 1905 based on intensity.
5. To make the public aware in their education of motion comfort plans on the basis of realistic grasps of the feasible consequences og the future earthquake is going to be happened in that particular region.

1.4 Union Of This Thesis

this work carried out to obtain 5 chapters. chapter(1) consists ofthe introduction phase of the significance of the ground action estimation in kangra region and gives the primary concept concept about the hazard that can happen through an earthquake of magnitude 8.0 or above With the sole objective of the study. Chapter(2) contains with Kangra hazard estimation,in this chapter the introduction of the losses two and lives and economic system is discussed. The chapter includes the assigned depth as per harm patterns in the stated regions. Chapter (3) comprises the floormotion evaluation based on depth to PGA conversion. Three kind of attenuation relations used for ground motion. Chapter(4) has DSHA method in the kangra region This chapter carries some important ground action predictive equations which helps to supply study of ground motins in terms of peak grond motions, peak ground velocity.Chapter(5) is about Kangra Earthquake of 1905 in this chapter theoretical based PGA calculated and In Chapter (6) final chapter which includes results anda conclusion of the thesis work.

Chapter 2 SEISMIC AND TECTONIC SETTING OF GREAT 1905 KANGRA EARTHQUAKE

In the Nothen section of the country there are numerous regional techtonic aspects in Himalayan area such as the Main Boundary Fault (MBF) and Main Central Thrust (MCT). These aspects are walking parallel to the strike size of Himalayas in the East-West direction. Along with the present regional techtonic aspects there addionally numerous lineaments which are walking transverse direction to Himalayan trend. Slow movements of these tectonic feature sresults in the building up of elastic stress in the crustal region.

The Great 1905 Kangra earthquake (M=8.0 on Richter's magnitude scale) has took place in the vicinity surrounding Dharmashala and Kangra region and also some villages falls under Kangra region, This region having traditionally excessive seismicity. This location falls in seismic zone 'V' of the seismic zoning map of India. This earthquake disrupted the farming and 53000 animal lives, the cost on economic scale for covering the earthquake were estimated at 2.9 million rupees,by then Punjab Govt.

In every of these quakes it is said the frontal hills of the Himalayas advanced in a few seconds more than 20 meters over the plains of India. However, seismologists have been at pains to factor out that historic references to earthquakes in the subcontinent have been shaky at best. the damage part in 1905 event is greater distinct in middlemiss fileand made depth map which is referred to as isoseismals. there are isoseismals is for besically two regions, first one for Kangra vicinity and second one for Dharmashala Region. the C.S.Middlemiss assigned the intensity on MMI scale to outline earthquake consequences in these two areas used to be X and VII respectively. Some of the principal tectonic aspects which are having sturdyworkable of producing an earthquake occasions are Main Boundary Thrust (MBT) and Main Crustal Thrust (MCT). In Actual, these two tectonic elements are walking parallel alongside the entire Alps-Himalayan tectonic belt. Several research & researches on seismotectonics of the place had been carried out by seismologist & scientist. Such a cartographical representation of past earthquakes and seismotectonics of this region is shown in Figure

Fig.1 State and district map of the region of interest, along with the major Himalaya tectonic features

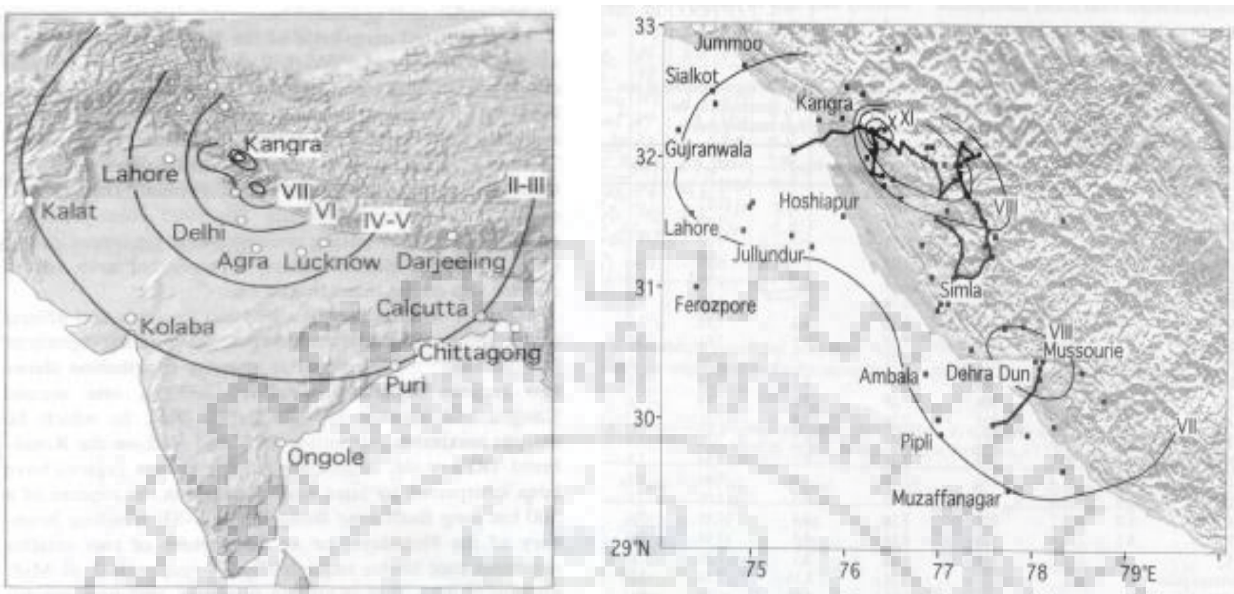

Fig.2 1905 Kangra Earthquake : Location map & isoseismal contours (GSI)

Fig.3 Epicentral Location of Kangra Earthquak(Source: Google.com)

2.1 Major tectonic zones in Kangra

1. MCT (Main central thrust)

It is lies between the greater Himalayas and lesser Himalayas. MCT was once actives at some stage in the early segment of Himalayan (Gupta2006). Based on preceding facts earthquake recorded in the MCT region have been 7.6 magnitude..

2. MBT (Main boundary thrust)

The MBT is a collection of thrusts that separates the Lesser Himalaya from the sub-Himalaya. It locate between the lesser Himalaya and Siwalik (DAHAL2006) Which has source of large earthquake and the earthquake occurred in this Region was Magnitude 8.0.

3 .MFT (Main frontal thrust)

The Main frontal Thrust is a primary geological fault where the Indian Plate has pushed beneath the Eurasian Plate alongside the Himalaya. The fault slopes down to the north and is uncovered on the floor in a NW-SE course (strike).

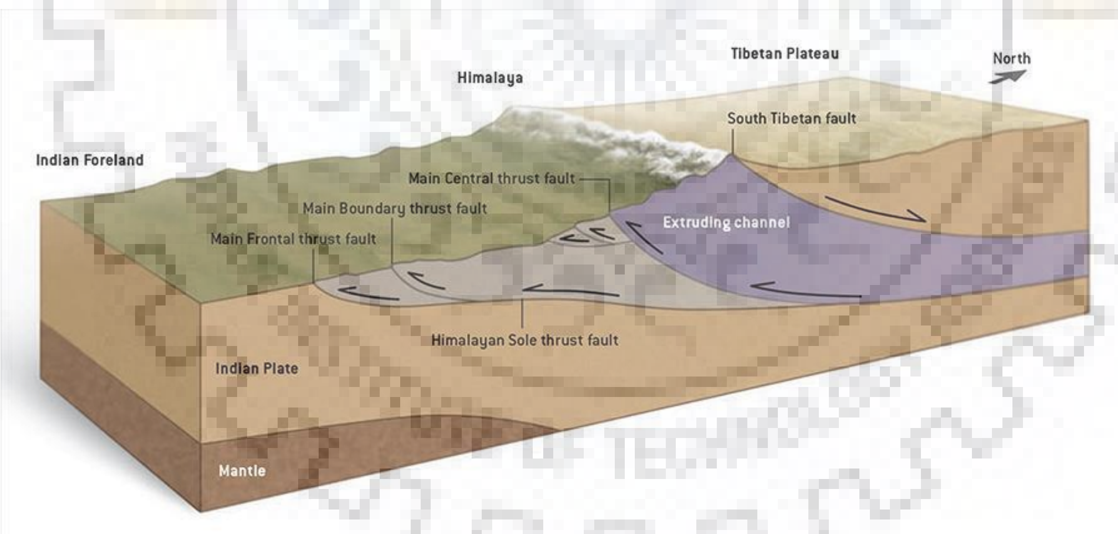

Fig 2.1 Major tectonic zones MCT, MBT, MFT (Source: DAHAL 2006).

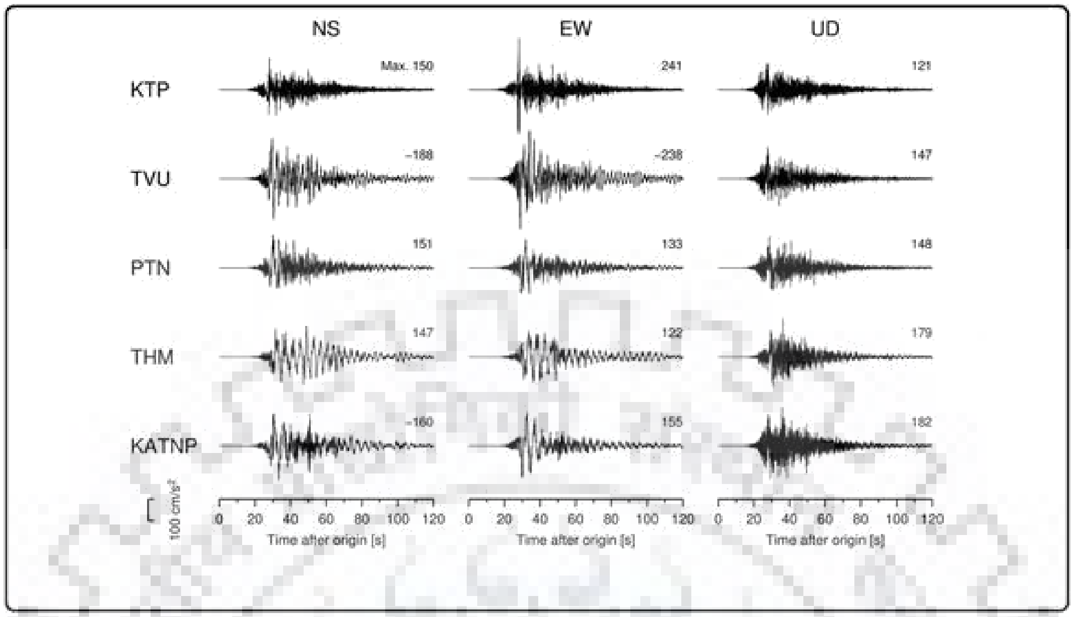

FIG 2.2 Soft sedimentary sites. The waveform records at 2 Observed ground accelerations at five stations. These have been corrected for the sensor-response; KTP is a rock site and the others are KATNP were provided by USGS (2015b) (Source: Usgs.com).

Chapter 3 OBSERVATION OF DAMAGE TO THE STRUCTURES

The very first and predominant detrimental impact of Kangra earthquake was considered at a city known as Shahpur. Shahpur is located at a distance of around fifty five km from Pathankot in the direction towards dharmshala. Inside city , stores located at roadsides had been completely collapsed and seemed as hundreds of sundried bricks. Also heavy slate roofs of the shopshad had been partly collapsed. In the residential area, roughly 1/2 of the constructions have been completely collapsed and remaining 1/2 percentage of the structures had grown to become nearly unfit for in addion use. Building in this location was ordinary and constructing substances used were ordinary sun-dried bricks rough in shape. At some places some of the buildings raised upto 17cm above the ground. Some structureshad been having slates as roof masking fabric while others have been the usage of thatch. Intensity assigned to damage Shahpur used to be vii. Luri, any harm at Luri was not clear altogether on the way. A Banglaw at Luri has not any splits. Suspension bridge on Sutlej waterway has appeared barely one or two breaks. Escalated here was ‘VIII’. Shimla has moreover endured overwhelming harm, entryways of the private buildings were stuck and bolted to each other firmly. Stack bearing dividers have appeared huge splits. Church windows were broken and a few were fallen aside and individuals ran out of the houses in fear. Concentrated at Shimla was ‘X’.

3.1 Harm to rubble work stone masonry houses

In Kangra most of the individuals live in houses of stone stone work held together by mud mortar this sort of houses are helpless to fragile amid the seismic tremor and have incredible ground shaking. In Kangra seismic tremor precipitous area like Bajura, sultanpur, saipari etc.had houses made of stone brick work and in these locale all the houses were severely harmed and cause misfortune of numerous lives.

Fig 3.1 harm to the stone Brick work houses in Kangra (Source :- google.com)

3.2 Structural damages to RCC Buildings

Nearly R.C.C buildings in Kangra are not more than 20 year ancient and such a building are comprise of R.C outline with infill divider of bricks the execution of R.C buildings in Kangra are not so much second rate because it ought to be since need of suitable plan code hone of building development in Kangra so amid seismic tremor the R.C buildings

Fig 3.2 RCC buildings damage in Kangra(Source:- Google.com)

At Haridwar , curves parallel to the north-east bearings were split delicately at crown. Number of breaks were created within the private buildings. Water was sprinkled out of an overhead water tank within the east-west heading. Boundary divider was broken. Concentrated was ‘VIII’. Saharanpur, a few breaks were seen within the corners of the private buildings. Curves parallel to the North-east were completely harmed whereas those parallel to the East-West were somewhat harmed. Books from racks were fell to the north course and hanging light bulbs were swung. Concentrated of harm was ‘VI’. Table showing escalated dissemination within the diverse areas/towns. underneath locale which are populated and thickness of the structures was tall which leads to extraordinary annihilation in these regions. Concentrated of seismic tremor was more than the othere zones in these locale

S.No.	TOWNS	LATITUDE	LONGITUDE	FROM EPICENTRE DISTANCE (Km)	INTENSITY (MMI)
1	Nurpur	32.3	75.9	23.97	5
2	Shahpur	32.212	76.18	22.07	7
3	Siapari	32.12	76.27	26.46	8
4	Shahpur region	32.21	76.17	18.80	8
5	Rehlu	32.1	76.27	26.70	9
6	Nerti village	32.1	76.26	25.40	10
7	Dharmshala	32.2	76.34	36.10	10
8	Dharmshala Cantt.	32.24	76.31	31.16	9
9	Kangra town	32.1	76.27	26.55	9
10	Palampur	32.11	76.54	58.89	10
11	Mandi	31.7	76.93	104.76	9
12	Bajura	32.96	77.12	153.13	9
13	Sultanpur	32.55	76.11	51.26	7
14	Manikarn	31.9	77.15	124.75	6
15	Nagger	32.11	77.16	123.82	6
16	Jibhi	31.63	77.35	154.66	8
17	Luri	31.34	77.42	174.25	8
18	Shimla	31.1	77.17	151.76	10
19	Dehradun	30.33	77.87	280.64	10
20	Dehradun cantt.	30.31	78.03	296.18	10
21	Rajpur	31.44	77.63	193.31	8
22	Mussoorie	30.45	78.07	291.4	9
23	Landour	30.45	78.08	292.9	9
24	Haridwar	29.93	78.14	334.93	8
25	Roorkee	29.87	77.89	322.17	7
26	saharanpur	29.96	77.51	287.38	6

Table no.2 showing intensity distribution in the different areas/towns

Chapter 4
INTENSITY AND DAMAGE ESTIMATION OF THE EARTHQUAKE

In the Kangra seismic tremor which was evaluated to a size of 8.0 on Richter scale, its harm potential to the lodging and private buildings in Kangra locale can be best assessed by watching the harm design and by cautious investigation of what happened amid 1905 seismic tremor in kangra locale. The degree of harm was too significantly impacted by the sort and number of houses within the locale.

INTENSITY

Escalated 4.0 and over on Modified Mercali Intensity scale was felt over expansive parts of Himachal Pradesh, Punjab and in a few parts of Haryana, Uttar Pradesh and Uttrakhand. The impact of Concentrated 6.0 was watched in five neighboring states, specifically, Himachal Pradesh, Haryana, Uttarakhand Jammu and Kashmir and Uttar Pradesh. In this venture, ranges beneath escalated 6.0 and underneath are not considered and as it were range as appeared within the different maps which are for the most part beneath concentrated 7.0 or over are considered for the think about. It was moreover watched that the ground movement parameters have been intensified within the S-W of the blame break, this happened due to the existance of Indo-Gangeti plain in that particular area.

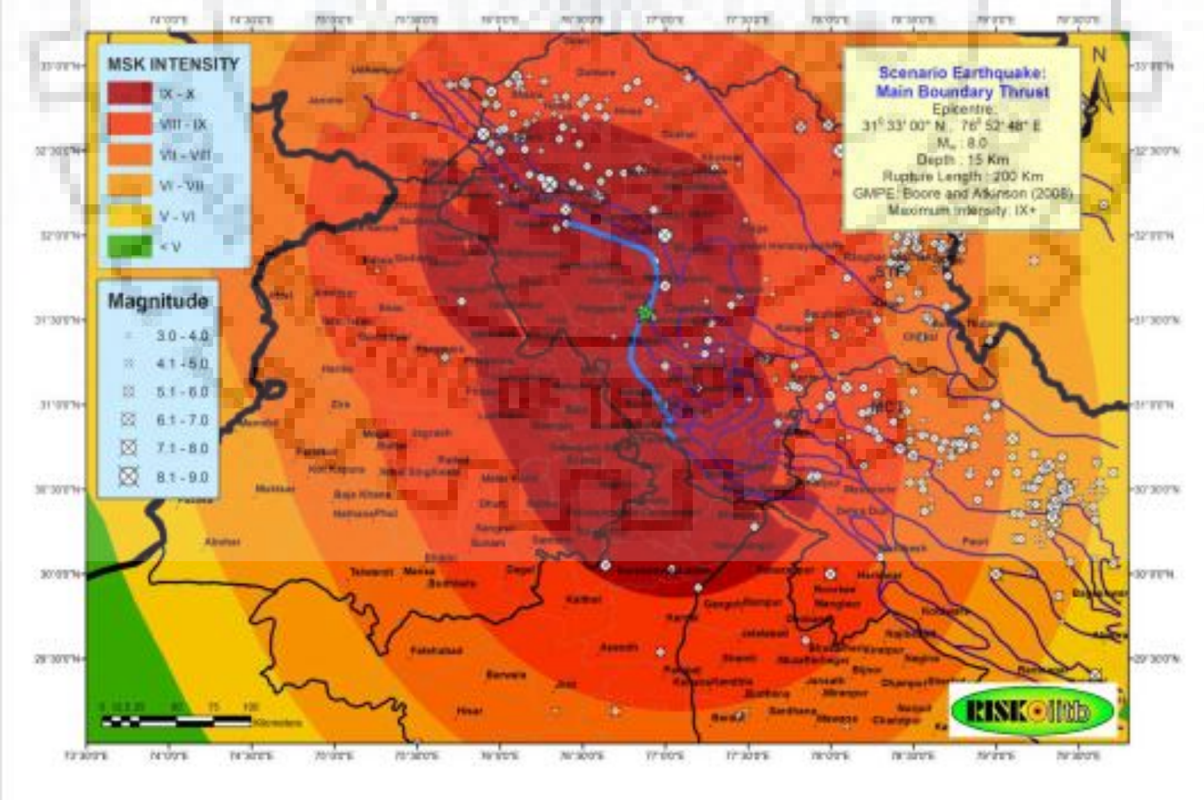

Fig 4.1 outline appearing ground shaking escalated due to situation earthquake

Intensity Area	**(in km$_2$)**
IX-X	56167
VIII – IX	87015
VII – VIII	86424
VI – VII	71852

Table no. 3 Earthquake intensity and different areas

Intensity	**Population(in lakhs)**
IX-X	231.8
VIII – IX	323.6
VII – VIII	251.6
VI – VII	136.3

Table no.4 Populace introduction beneath distinctive earthquake concentrated

Fig 4.2 Himanchal Pradesh Earthquake Danger outline

Chapter 5 DSHA APPROACH FOR KANGRA REGION

5.1 Deterministic Seismic Hazard Analysis

“Seismic risk investigation includes the quantitative estimation of ground shaking risk at a specific location it may be measured by the level of shaking for the duration of the earthqukae , crest ground increasing speed in other words.it can be examined deterministically as when a precise earthquake situation is accepted in which vulnerabilities in eaarthquake estimate, area and time of event are considered.. DSHA method consist of four step process

1) Recognizable proof and characterization of all seismic tremor sources competent of producing critical ground movement at the location. Source characterization includes definition of each source’s geometry (the source zone) and earthquake potential.

2) Determination of a source-to-site remove parameter for each source zone. In most DSHA’s he most limited remove between the source zone and the location of intrigued is selected. The remove may be communicated as an epicentral remove or hypocentral separate, depending on the degree of separate of the predictive relationship(s) utilized within the taking after step.

3) Choice of the controlling earthquake (i.e., the earthquake that's anticipated to produce the most grounded level of shaking), for the most part communicated in terms of some ground movement parameter, at the location. The choice is made by comparing the levels of shaking delivered by earthquakes (distinguished in step 1) accepted to occur at the separations recognized in step 2. The controlling earthquake is depicted in terms of its measure (more often than not communicated as greatness) and distance from the location.

4) The danger at the location is formally characterized, more often than not in terms of the ground motions created at the location by the controlling earthquake. Its characteristics are ordinarily depicted by one or more ground movement parameters gotten from predictive connections of the sorts displayed in chapter 3. Peak acceleration, peak velocity, and response spectrum ordinates are commonly utilized to characterize the seismic hazard.

This strategy is traditionalist in spite of the fact that in conditions like dam and atomic control Plant whose disappointment lead to fantastic annihilation. Some of the time it gives most exceedingly bad case ground movements without any issues. DSHA has a few confinements with respect to not able to supply any data on the followings:-

1. The likelihood of controlling earthquake’s occurrence.
2. The likelihood of its incidence the place it’s supposed to came about.
3. The plausibility of danger amid a limited period of time.
4. Effects of vulnerabilities created within the a few steps at the time of computation of ground movement characteristics”.

OBJECTIVES

In this consider our work will be arranged to the taking after goals. For this we'll be utilizing the concept of Geographic data framework (Arc GIS) for estimation of solid ground movement for the locale area of Kangra.

1) First goal is to get isoseismals on MMI scale covering the think about range. These isoseismals will be demonstrating most noteworthy two pressure experienced at the epicentral and encompassing locale. This isoseismals will be built by using the assessment of macroseismic information gotten from Kangra seismic tremor of 1905. Macroseismic impacts and harm design of Kangra seismic tremor have been carefully examined by C. S, midllemiss and this statistic information archived by C. S, midllemiss was once utilized utilized right here.

2) Next, goal is to gauge the solid ground movement close and around epicentral locale of the Kangra seismic tremor. This will be accomplished by considering the impact of diverse conceivable seismotectonic sources mapped within the think about zone

3) Final To appraise the solid ground movement delivered by Kangra soil of 1905 based on concentrated based attenuation relations.

GIS APPROACH IN LOCAL KANGRA AREA

In this ponder, the Kangra locale has been chosen for the reason of assessing the solid ground movement. This locale is found within the N-W locale of the nation. This region is one of the foremost structurally unsteady and seismically dynamic locale within the world. This zone is profoundly inclined to expansive seismic tremors and seismic risks. At show time require of proper seismic tremor safe plan of structures has ended up highly essential due to extend in populace thickness and thus private buildings within the locale In this consider we'll be utilizing the information and data from accessible database of deficiencies, tectonics, seismicity and appropriate ground movement constriction relations for Kangra place

CONSIDER REGION

To begin with of all, Scope and longitude of the Kangra subregion were gotten and a network is built over the consider range. This encased range interior the lattice is having a add up to of 126 points/nodes such that epicenter of Kangra earthquake falls inside the choosen zone. At that point utilizing ArcGIS 10 computer program, the most limited remove between diverse blame crack to each of these points/nodes are measured and this information is arranged in table comparing to these issues. Arranges of the rectangular zone beneath consider changes from 75°12' E to 77°36' E and 31°24' to 33°00' N. Each encased framework is of 0.2°*0.2° or 12'*12' square. Most limited Separate of each hub is measured from major blame bursts to be specific MCT MBT MFT. This most limited remove is called Rjb and is organized against each hub together with their latitudes and longitudes in a exelsheet.

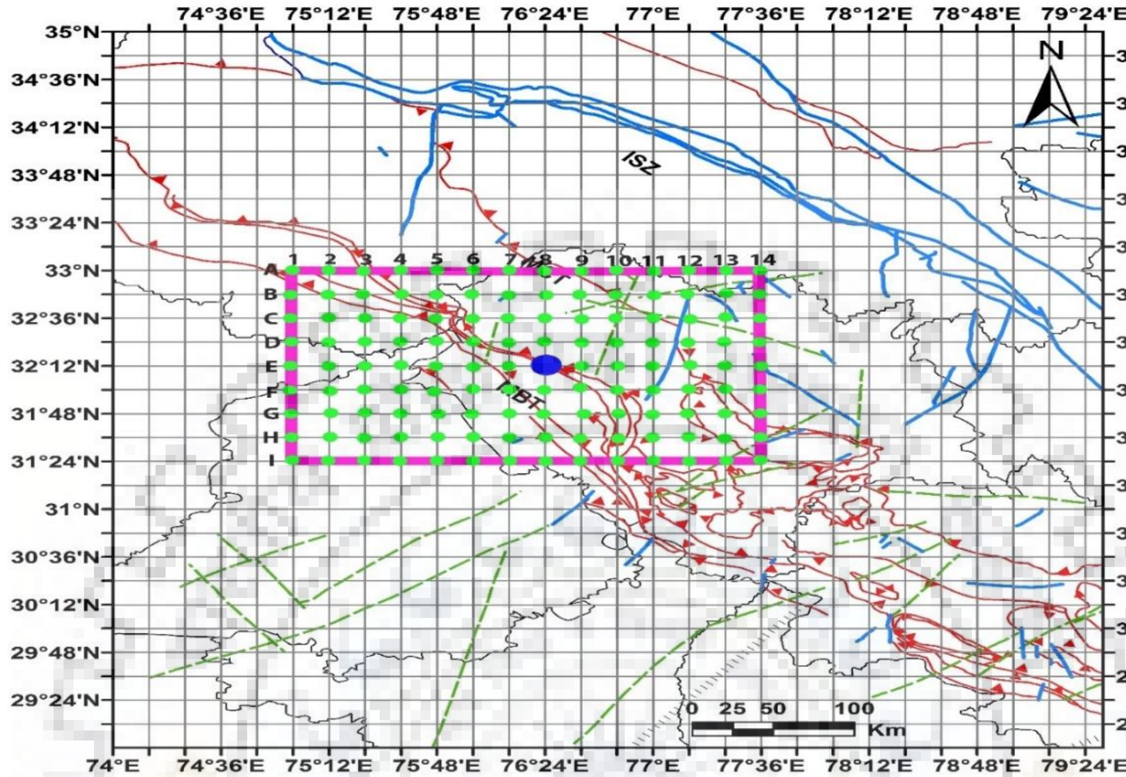

Fig 5.2 appearing area of range under consideration(Source:-ArcGis Map)

CHAPTER 6

GROUND MOTION PREDICTION EQUATIONS UTILISIED FOR DSHA

The taking after ground motion prediction equations were utilized to assess the PGA values at distinctive Hub points of the network during Kangra earthquake.

i.) FUKUSHIMA & TANAKA 1990

ii.) JOYNER AND BOORE 1981

iii.) AKKAR & BOOMER 2010

6.1 Fukushima & Tanaka (1990)

Ground motion model is

$\text{Log } A = a \times M - \log(R + c \times 10^{aM}) - b \times R + d$

Where A is in cm/s^2, a=0.41, b=0.0034, c=0.032, d= 1.30,

There are four site categories for some local geological conditions.

1. **Rock sites**:

2. **Hard site**: these site are ground above tertiary periods or thickness of Alluvial deposit is above bedrock <10 m

3. **Medium**: the thickness of alluvial deposit above bedrock> 10m, or thickness of alluvial deposits above bedrock<10m, or thickness of alluvial deposit< 25m and thickness of soft deposit is <5m,

4. **Soft soil**: other soft ground such as reclaimed land.

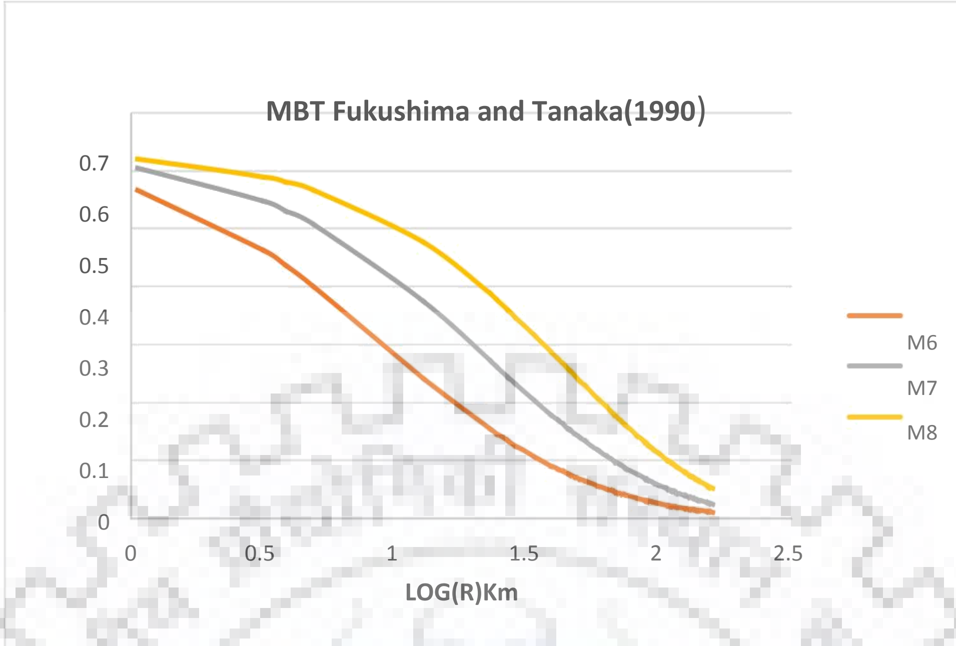

Fig 6.1 Fukushima and Tanaka (1990) variation of PGA vs R for MBT for Different magnitude

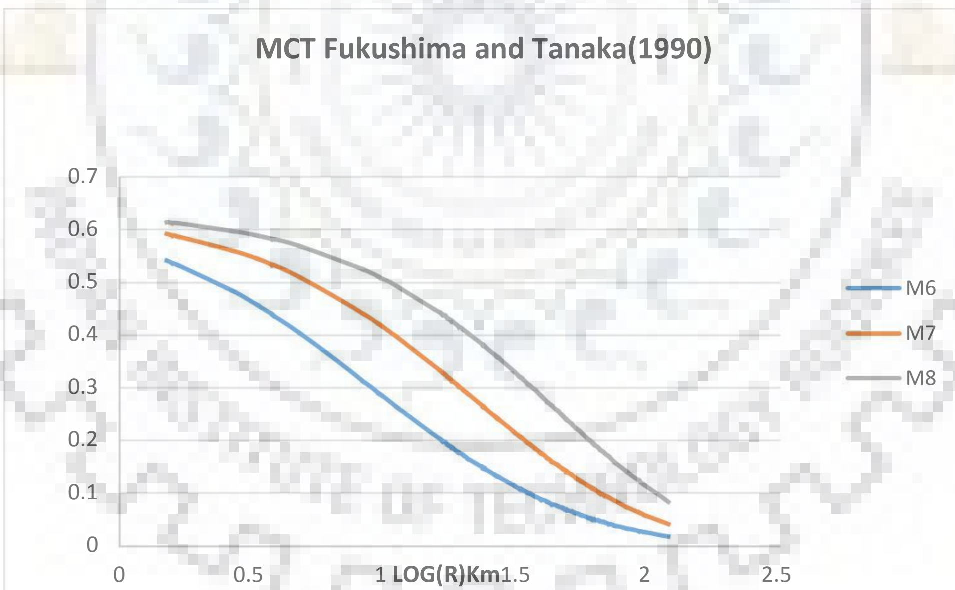

Fig 6.2 Fukushima and Tanaka (1990) variation of PGA vs R for MCT for Different magnitude

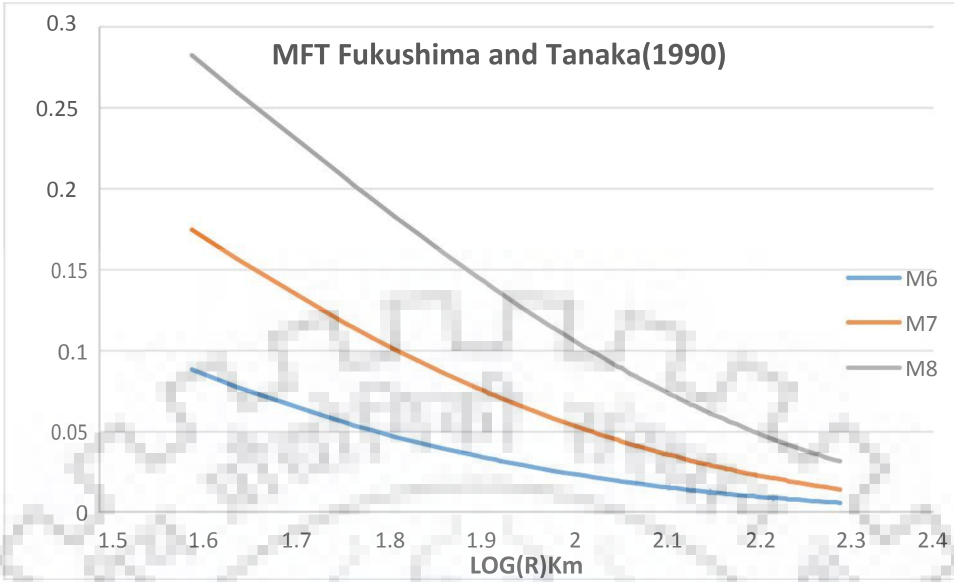

Fig 6.3Fukushima and Tanaka 1990 variation of PGA vs R for MFT for Different magnitude

6.2 JOYNER & BOORE (1981)

Ground-motion model is:

LOGY= a + b×M − logR + c× R where R = $(d^2 + h^2)^{1/2}$ where y is in g, a =−1.02, b = 0.249, c =−0.00255, h = 7.3

• Use two site categories (not all records have category):

S = 0 Rock: sites described as granite, diorite, gneiss, chert, greywacke, limestone, sandstone or siltstone and sites with soil material less than 4 to 5m thick overlying rock, 29 records. Indicate caution in applying equations for M > 6.0 due to limited records.

S = 1 Soil: sites described as alluvium, sand, gravel, clay, silt, mud, fill or glacial outwash except where soil less than 4 to 5m thick, 96 records.

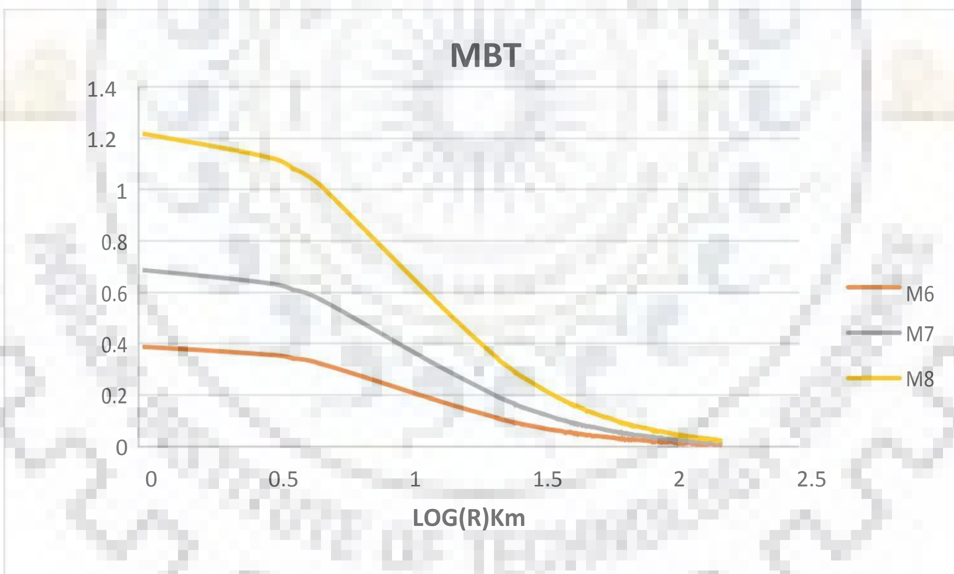

Fig 6.4 JOYNER & BOORE (1981) variation of PGA vs R for MBT for Different magnitude

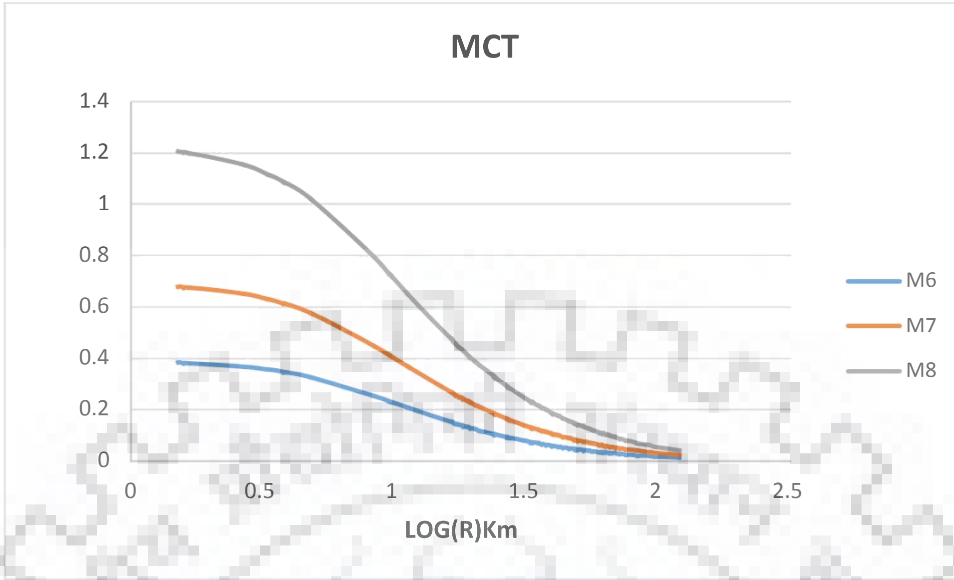

Fig 6.5 JOYNER & BOORE (1981) variation of PGA vs R for MCT for various magnitude

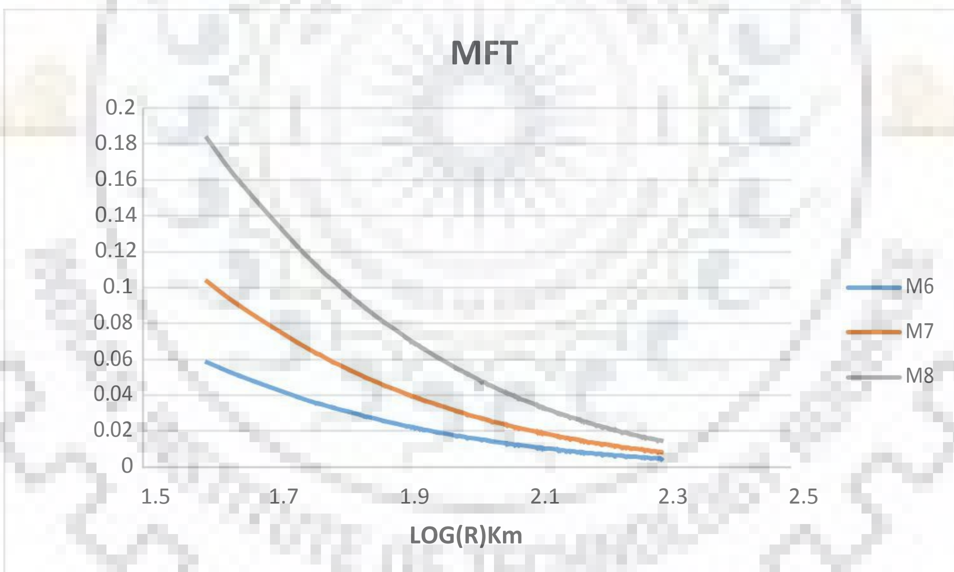

Fig 6.6 JOYNER & BOORE (1981) variation of PGA vs R for MFT for various magnitude

6.3 AKKAR & BOMMER (2010)

Ground-motion model is:

$$\log y = b_1 + b_2 \times M + b_3 \times M^2 + (b_4 + b_5 \times M) \times \log[(R_{jb})^2 + (b_6)^2]^{1/2} + b_7 \times SS + b_8 \times SA + b_9 \times FN + b_{10} \times FR$$ **where y is in cm/s^2.**

b_1= 1.04159, b_2 = 0.91333, b_3 =−0.08140, b_4 =−2.92728, b_5 = 0.28120, b_6 = 7.86638, b_7 = 0.08753, b_8 = 0.01527, b_9 = −0.04189, b_{10} = 0.08015

Three site categories:

Soft soil SS = 1, SA = 0.

Stiff soil SA = 1, SS = 0.

Rock SS = 0, SA = 0.

Three faulting mechanism categories:

Normal FN = 1, FR = 0.

Strike-slip FN = 0, FR = 0.

Reverse FR = 1, FN = 0.

In this equation we considered only **rock soil** (SS=0, SA=0) and **strike slip** fault category (FN =0, FR=0) for Nepal region.

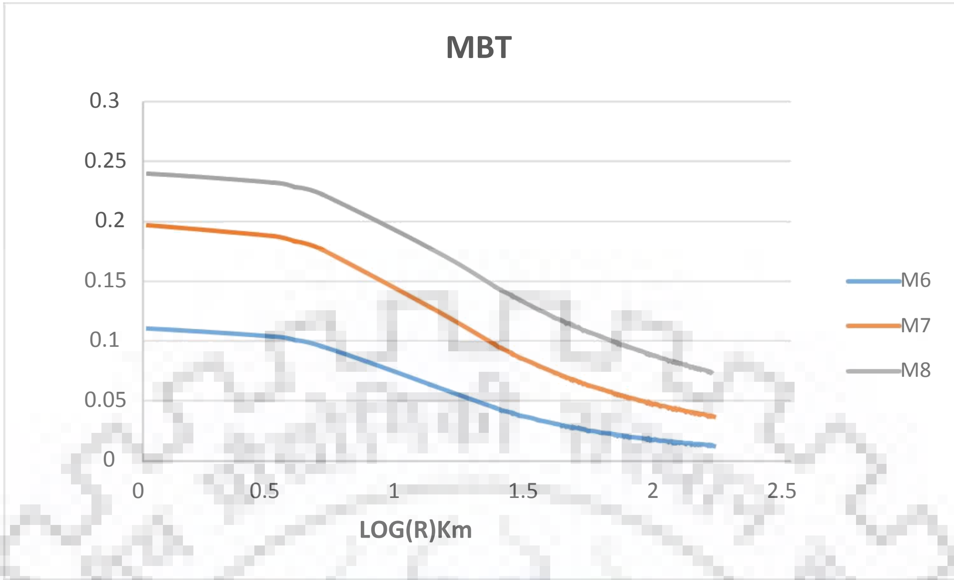

Fig 6.7 AKKAR AND BOOMER 2010 variation of PGA vs R for MBT for various magnitudes

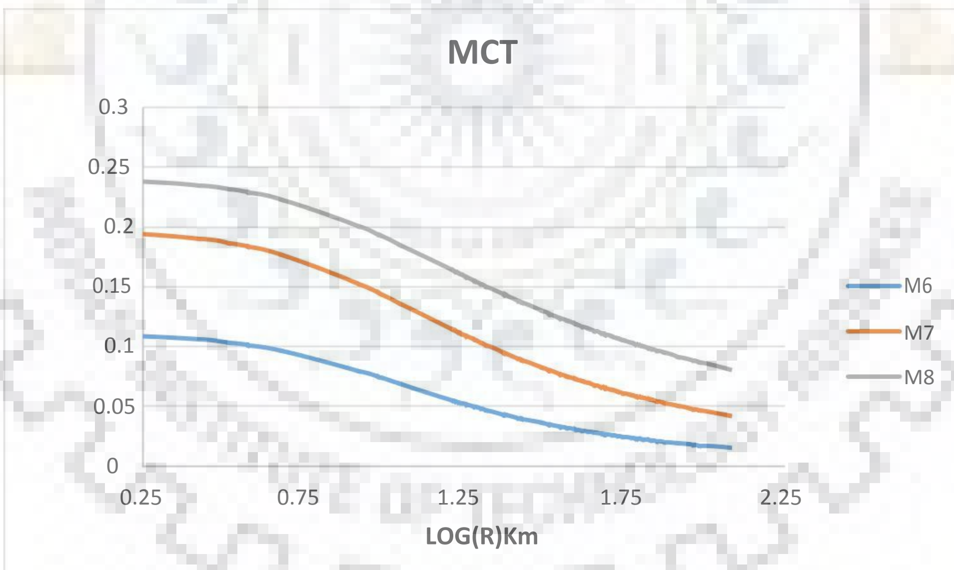

Fig 6.8 AKKAR AND BOOMER 2010 variation of PGA vs R for MCT for various magnitudes

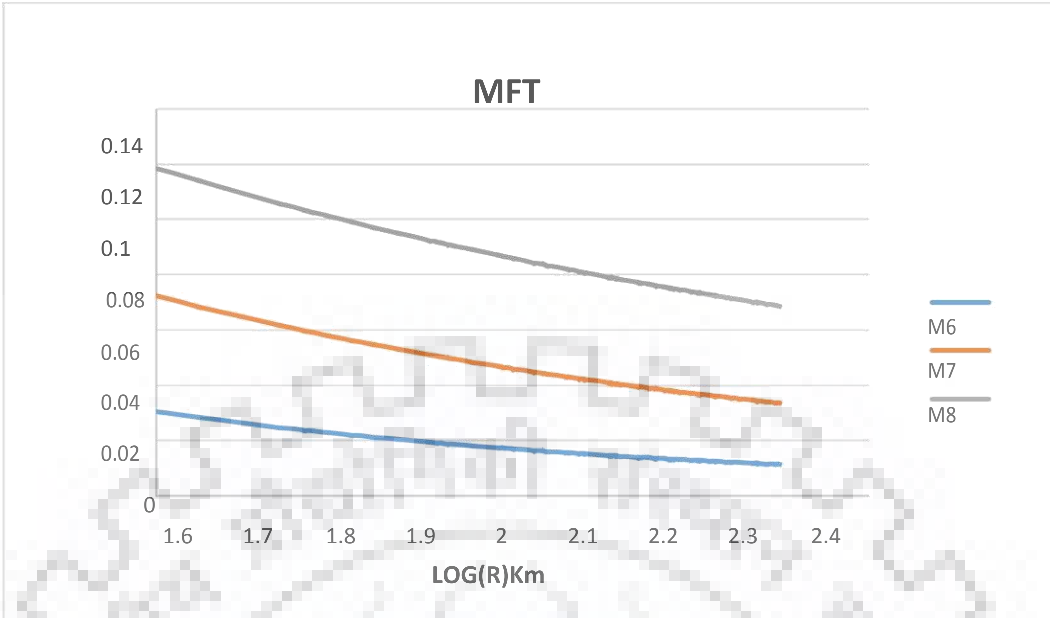

Fig 6.9 AKKAR AND BOOMER 2010 variation of PGA vs R for MFT for various magnitudes

CHAPTER 7
Determination of PGA value utilizing by Intensity based attenuation relationships

After kangra earthquake,damge design was inspected by obsrververs and reasonable concentrated was relegated to the different region.During kangra earthquake, reverberation and sufficiency enhancement of surface waves took put nearly more than 100 km distant from epicenter of 1905 seismic tremor. The soil display in that locale of Dehradun which made waves to open up and destruct the private structures exceptionally badly.maximum escalated for the harm in Dehradun & mussoorie locale was VII whereas for kangra locale greatest escalated doled out was X

There are two kind of attenuation relation utilized to calculate the PGA on intensity basis

1. **Iyenger and Raghu Kanth (2003)**

The relation is as

Ln(PGA) = 0.6782*MMI-6.8163

Where PGA is in ‘g’

And MMI is intensity observed

Table 5 From information observed during Kangra earthquake ,PGA by Iyenger and Raghu Kanth

S.NO.	TOWNS	LATITUDE	LONGITUDE	MMI	PGA
1	Nurpur	32.3	75.9	5	0.0004
2	Shahpur	32.212	76.18	7	0.0085
3	Siapari	32.12	76.27	8	0.0407
4	Shahpur region	32.21	76.17	8	0.0407
5	Rehlu	32.1	76.27	9	0.1938
6	Nerti village	32.1	76.26	10	0.9240
7	Dharmshala	32.2	76.34	10	0.9240
8	Dharmshala Cantt.	32.24	76.31	9	0.1938
9	Kangra town	32.1	76.27	9	0.1938
10	Palampur	32.11	76.54	10	0.9240
11	Mandi	31.7	76.93	9	0.1938
12	Bajura	32.96	77.12	9	0.1938
13	Sultanpur	32.55	76.11	7	0.0085
14	Manikarn	31.9	77.15	6	0.0017
15	Nagger	32.11	77.16	6	0.0017
16	Jibhi	31.63	77.35	8	0.0406
17	Luri	31.34	77.42	8	0.0406
18	Shimla	31.1	77.17	10	0.9240
19	Dehradun	30.33	77.87	10	0.9240
20	Dehradun cantt.	30.31	78.03	10	0.9240
21	Rajpur	31.44	77.63	8	0.0406
22	Mussoorie	30.45	78.07	9	0.1938
23	Landour	30.45	78.08	9	0.1938
24	Haridwar	29.93	78.14	8	0.0406
25	Roorkee	29.87	77.89	7	0.0085
26	saharanpur	29.96	77.51	6	0.0017

With the assistance of this table ready to see the arrange of PGA comparing to the intensity from V to X, as there was not any intensity lesser than V within the Kangra locale. So the PGA value from V to X calculated as follows:

S.NO.	INTENSITY	PGA
1	V	0.03
2	VI	0.06
3	VII	0.13
4	VII	0.26
5	IX	0.52
6	X	1.03

As The PGA values goes on expanding as the concentrated increments. For the case of X concentrated the PGA is 1.03, this recommend the unwavering quality of C.S Midllemiss , who said within the journals of geographical study of india that the ground movement surpassed more than the speeding up due to gravity in a few zones. A few individuals had seen amid earthquake that the stone on the ground jumped upto a stature within the discuss. Devastation in those region was exceptionally perilous and each structure in that region was totally harmed

Plot of graph between Iyenger and Raghu Kant and PGA(g) is as follows:

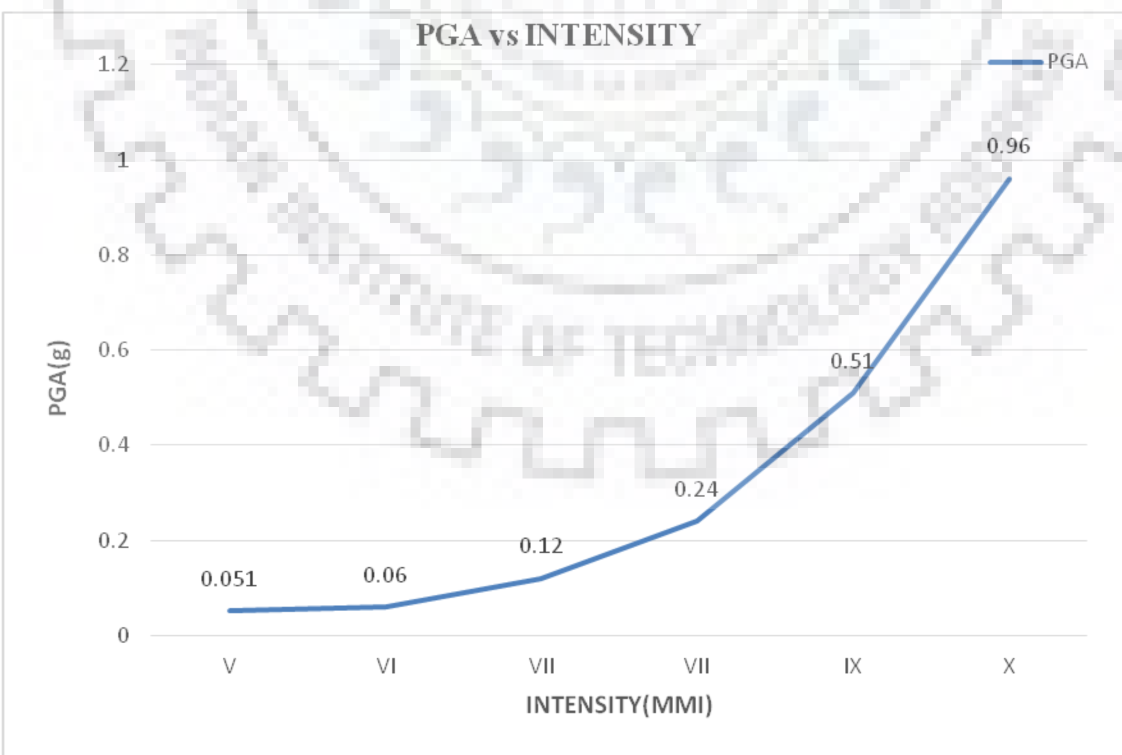

Fig 7.1 plot of Intensity vs PGA

Chapter 8

Using NGA Model Approach for estimation of PGA

Using NGA association Chou and Young's 2008 ton get the PGA esteems for particular issues and for different sizes of Kangra area by taking qualities agreeing to the district This NGA appear by Chou and Young's 2008 thinks about various neighborhood area condition parameters and predicts basically exact PGA. Vs30 used in this NGA demonstrate was 760 m/s for Kangra area since it is found in firm soil and direct troublesome Shake area. Profundity of Fault split taken used to be 15 km for considering most outrageous PGA in a most exceedingly awful case circumstance. ZTOR is taken as 7 Km and width of accuse taken was 15km. It is obviously appeared from these plots that PGA (g) is alternately relating to the Log(R). Higher PGA esteems evaluated are near the reprimand MBT, MCT, MFT

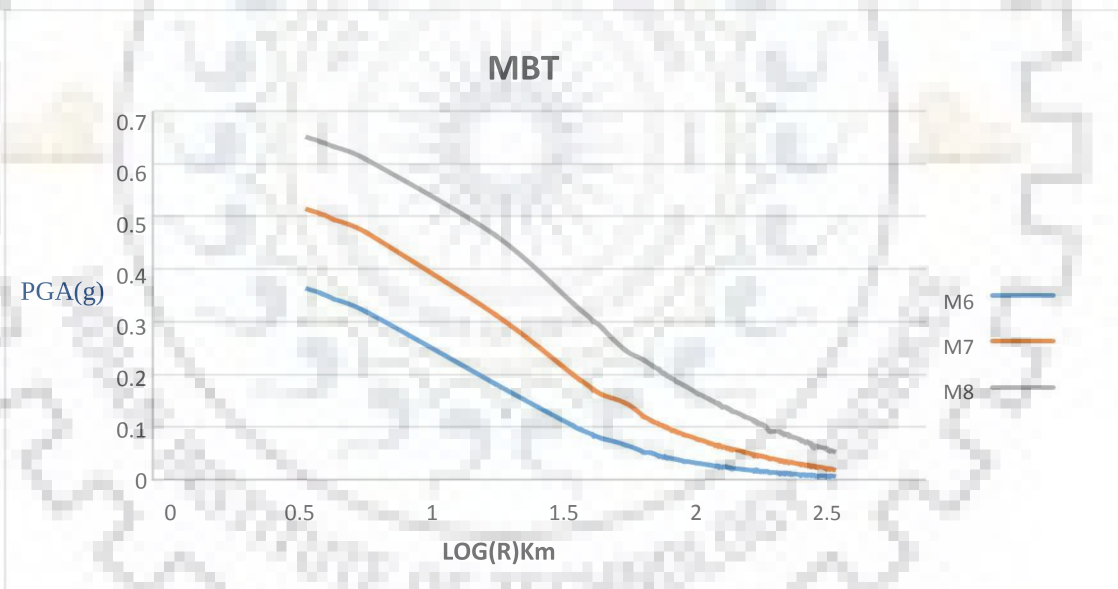

Fig 8.1 CHIOU & YOUNGS 2008 variation of PGA vs R of MBT for different magnitudes

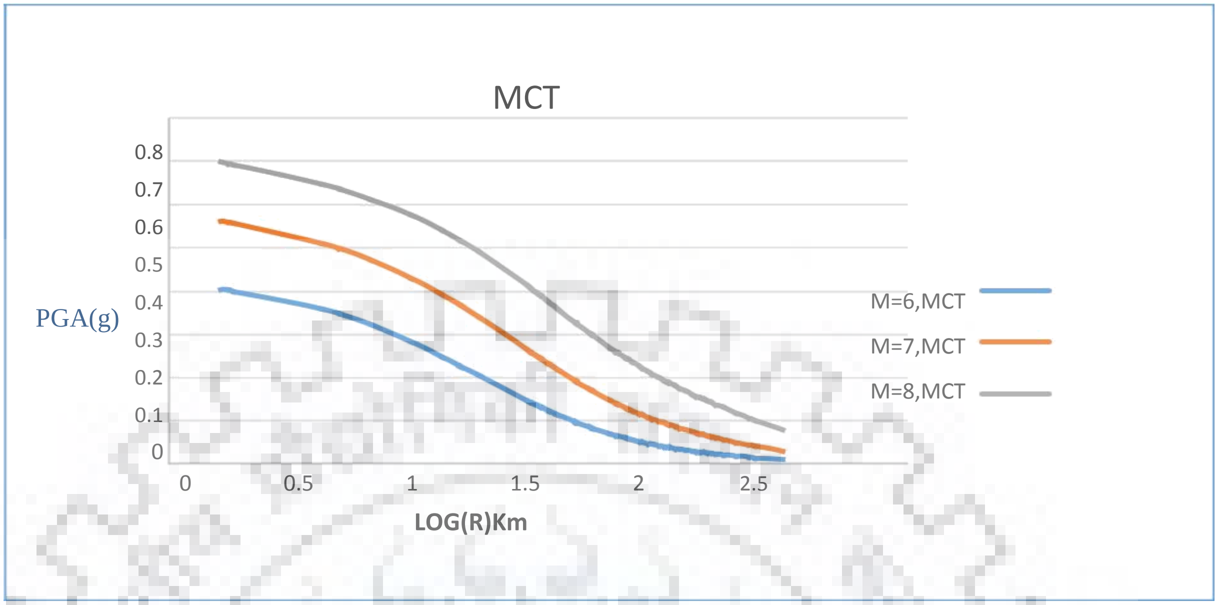

Fig 8.2 CHIOU & YOUNGS 2008 variation of PGA vs R of MCT for different magnitudes

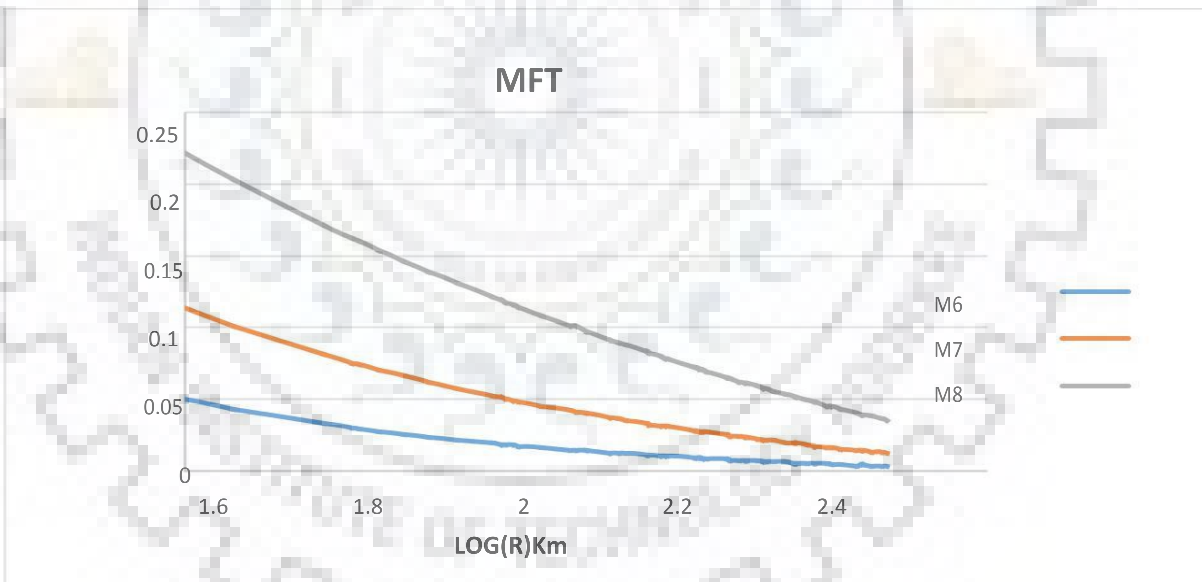

Fig 8.3 CHIOU & YOUNGS 2008 variation of PGA vs R of MFT for different magnitudes

Chapter 9
Comparison of GMPEs

The different input parameters are used in every ground prediction equation that are earlier study This has led to variation in PGA value for same magnitude and same fault distance .the following graphs are show to obtained to show comparison of the three GMPEs for same magnitude for same fault.

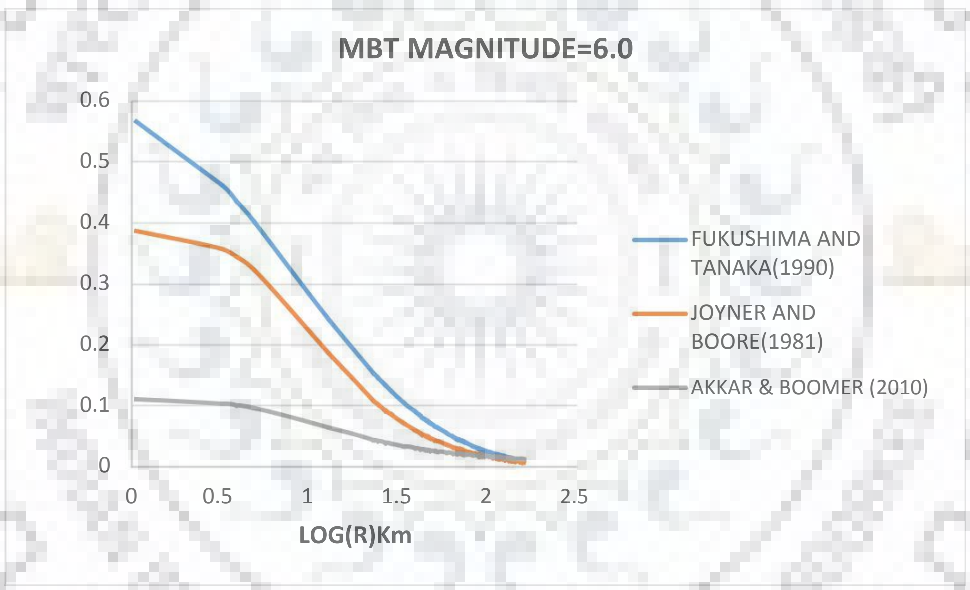

Fig 9.1 Comparison of all GMPEs for PGA vs R for MBT for M=6.0

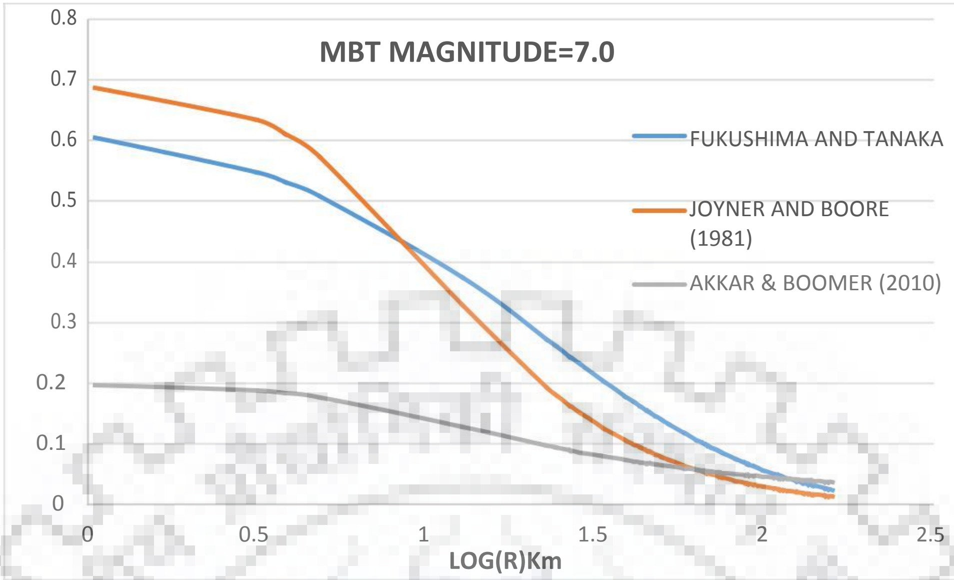

Fig 9.2 Comparison of all GMPEs for PGA vs R for MBT for M=7.0

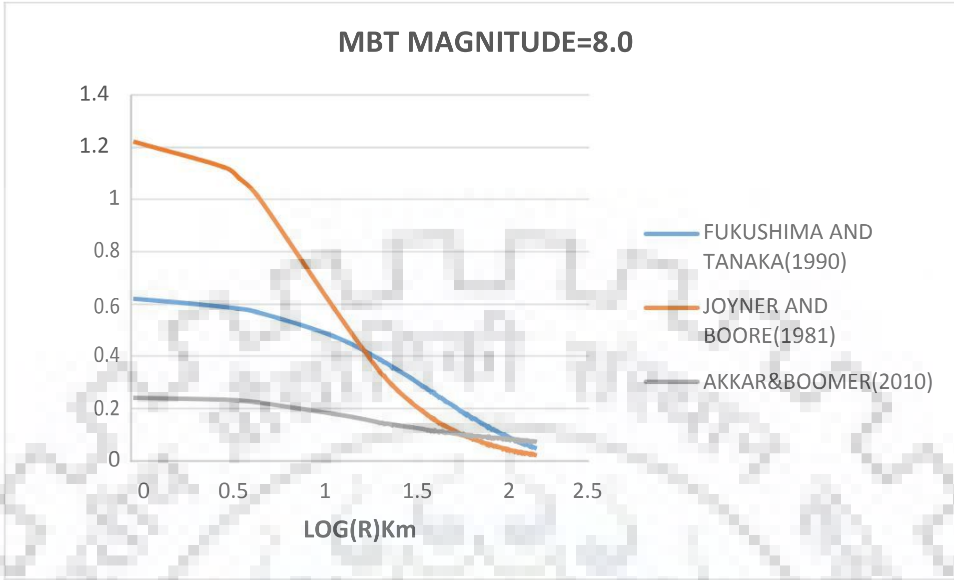

Fig 9.3 Comparison of all GMPEs for PGA vs R for MBT for M=8.0

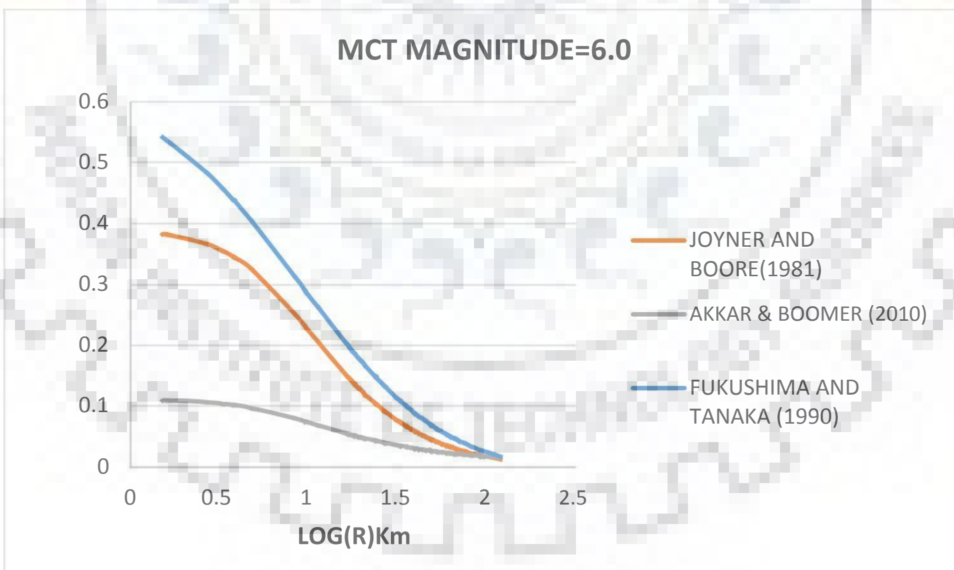

Fig 9.4 Comparison of all GMPEs for PGA vs R for MCT for M=6.0

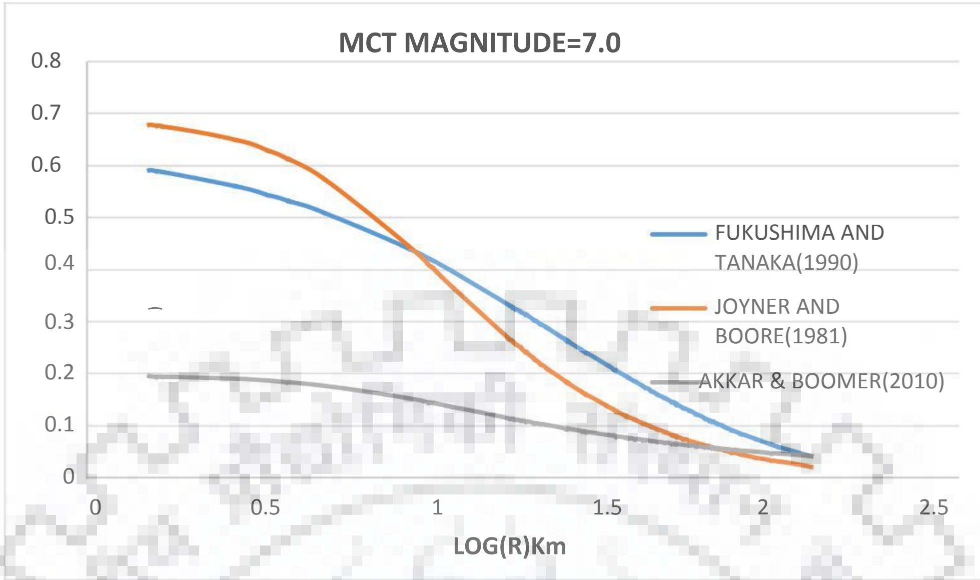

Fig 9.5 Comparison of all GMPEs for PGA vs R for MCT for M=7.0

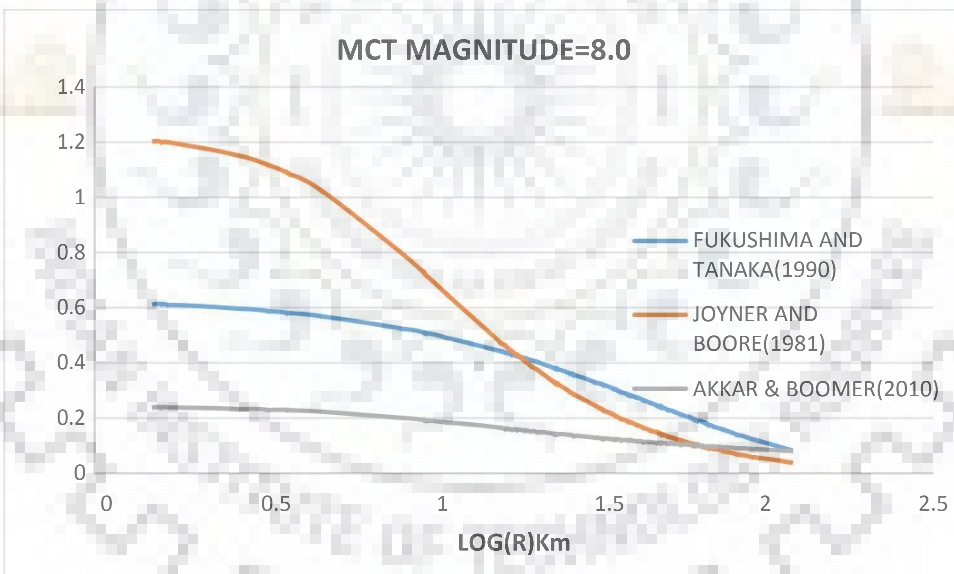

Fig 9.6 Comparison of all GMPEs for PGA vs R for MCT for M=8.0

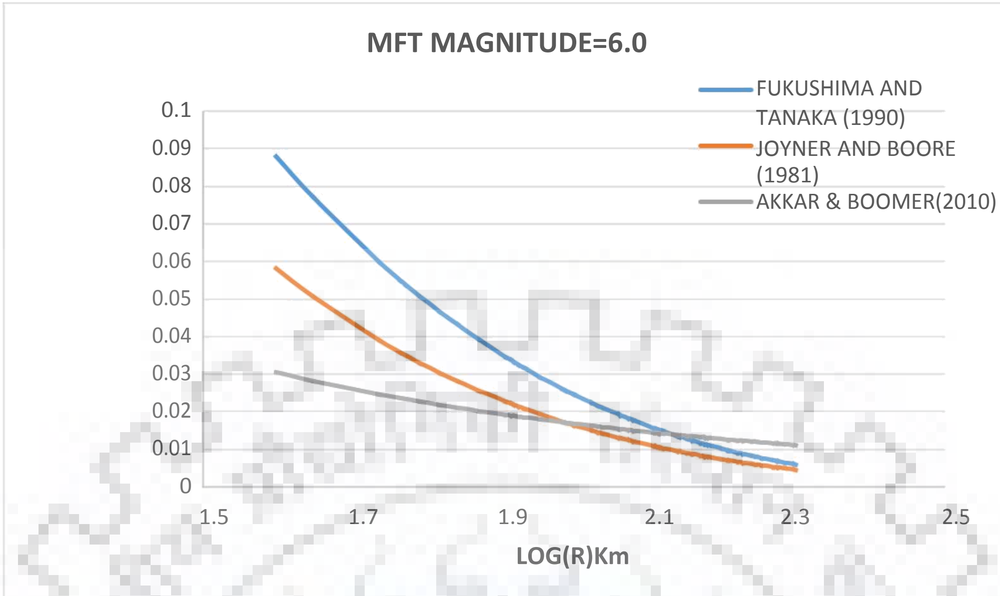

Fig 9.7 Comparison of all GMPEs for PGA vs R for MFT for M=6.0

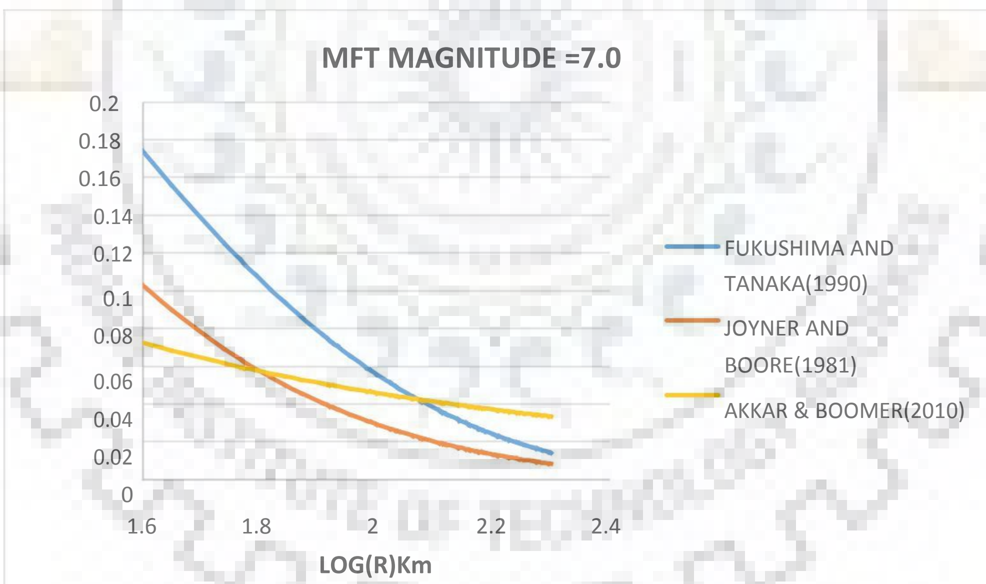

Fig 9.8 Comparison of all GMPEs for PGA vs R for MFT for M=7.0

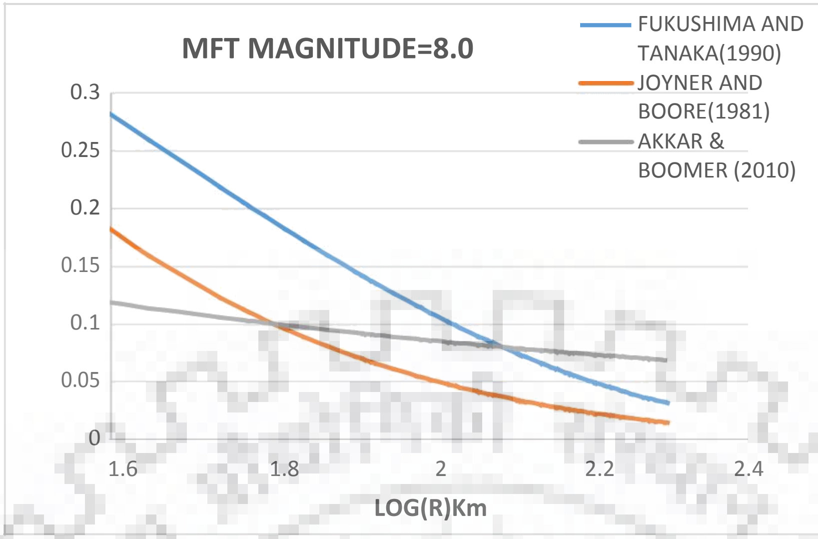

Fig 9.9 Comparison of all GMPEs for PGA vs R for MFT for M=8.0

Chapter 9 RESULTS

In this work the estimation of peak ground acceleration(PGA) is completed. PGA esteems so acquired were plotted against Log(R) with the end goal that PGA is as far as 'g' and R is in Km as measure in ArcGIS 10. The chart acquired demonstrates the variety of PGA with expanding separation Rjb from the closest blame. With close examination of the plot plainly PGA esteem for a specific hub for same separation is bring down for 5 extent seismic tremor than for 6 size quake which is further lower than that for 7 size earthquake thus on.This demonstrates that the peak ground increasing speed straightforwardly corresponding to the earthquake size is contrarily relative to the separation of the closest purpose of the fault rupture

PGA estemation ascertained from various GMPEs for various deficiencies like MBT,MFT,MCT For various Magnitude. The accompanying table displays the got comes about because of examination

Table 6. Calculated corrospondings PGA values for MBT, MCT, MFT for Magnitude 6,7,8

GMPEs USED	**M=6**			**M=7**			**M=8**		
	Max PGA Value 'g'			Max PGA Value 'g'			Max PGA Value 'g'		
	MBT	**MCT**	**MFT**	**MBT**	**MCT**	**MFT**	**MBT**	**MCT**	**MFT**
FUKUSHIMA AND TANAKA (1990)	0.566	0.532	0.087	0.604	0.589	0.17	0.620	0.61	0.28
JOYNER AND BOORE(1981)	0.386	0.381	0.058	0.686	0.678	0.10	1.2	1.2	0.18
AKKAR & BOOMER (2010)	0.110	0.109	0.030	0.196	0.194	0.072	0.240	0.23	0.11
Avg Max PGA	0.360	0.340	0.058	0.495	0.487	0.114	0.686	0.680	0.190

Expected PGA Value on MBT, MCT, MFT

PGA by GMPEs on MBT for M =8.0 is 0.73g

PGA by NGA on MBT for M =8.0 is 0.69

Average PGA value is 0**.70 g** expected on MBT for M=8.0

PGA by GMPEs on MCT for M =8.0 is 0.63g

PGA by NGA on MCT for M =8.0 is 0.70g

Average PGA value expected on MCT is 0**.65g** for M = 8.0

PGA by GMPEs on MFT for M =8.0 is 0.19g

PGA by NGA on MFT for M =8.0 is 0.22g

Average PGA value expected on MFT is 0**.20g** for M=8

CONCLUSION

The seismic risk within the ponder region is of significant significance from seismological and structure see and the esteem of Crest ground increasing speed is utilizing three distinctive approaches to begin with one by utilizing D.S.H.A Strategy utilizing distinctive GMPEs besides utilizing escalated observational Relations to assess PGA of Kangra locale and in conclusion utilizing NGA approach to gauge the PGA value of watched locale This work has been an exertion in estimation of top ground increasing speed (PGA) around Kangra locale amid utilizing diverse ground movement attenuation relationships.

Using DSHA Method by using GMPEs are AKKAR & BOOMER (2010), FUKUSHIMA AND TANAKA(1990),JOYNER AND BOORE(1981) we observed following as

By using AKKAR & BOOMER (2010)

1. The range of PGA value for MFT is 0.011g to 0.12g.
2. The range of PGA value for MCT is 0.015g to 0.24g.
3. The range of PGA value for MBT is 0.012g to 0.28g

By using JOYNER AND BOORE (1981)

1. The range of PGA value for MFT is 0.011g to 0.18g.
2. The range of PGA value for MCT is 0.030g to 1.1g.
3. The range of PGA value for MBT is 0.023g to 1.2g

By using FUKUSHIMA AND TANAKA (1990)

1. The range of PGA value for MFT is 0.014g to 0.280g.
2. The range of PGA value for MCT is 0.018g to 0.610g.
3. The range of PGA value for MBT is 0.023g to 0.621g

CHIOU & YOUNG'S 2008 NGA model gives the PGA value range for MBT is 0.2g to 0.65g, For MCT is 0.031g to 0.70g, for MFT is 0.12g to 0.22g.

Thus estimations of strong ground motion in terms of PGA in the region of Nepal are as following.

1. Seismic hazard assessment is considerably important in Nepal from seismological and structure point of view.
2. The level of ground shaking is more on MBT as compare to MCT and MFT.
3. JOYNER AND BOORE gives max. PGA value for earthquake magnitude above 6.0
4. By NGA approach max Average PGA value is 0.50g , 0.58 g and 0.128 g for MBT , MCT and MFT respectively.
5. Maximum PGA estimated using Intensity based relation is approximately 0.72g
6. Maximum Average PGA estimated based on DSHA analysis is around 1.2g (using JOYNER AND BOORE

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