



2014 年 3 月 30 日湖北省秭归 M4.7 地震房屋震害特征分析^①

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摘要:2014 年 3 月 30 日湖北省秭归县发生 M4.7 地震,震中烈度Ⅵ度,地震对震中区的房屋造成了不同程度的损坏。通过对震中区房屋震害情况进行抽样统计和分析,归纳总结了农村两种常见类型房屋的典型震害特征,并对其原因进行深入的分析。在此基础上,对农村民居的场地选择及设计施工等提出一些建议,可以为灾区及其他抗震设防地区的农居建设及政府决策提供依据和参考。

关键词:秭归 M4.7 地震; 房屋震害; 抽样统计; 农村民居; 抗震设防

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Building Damage Characteristics during the Zigui, Hubei M4.7 Earthquake on March 30, 2014

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Abstract: On March 30, 2014, a M4.7 earthquake occurred in the Zigui county, in Hubei province. The epicenter intensity reached Ⅵ. The earthquake caused various degrees of damage to houses in the epicentral area. According to on-site investigation data conducted after the earthquake, through the sampling statistics and analysis on house damage in the epicentral area, two typical and common house damages in rural areas are summarized in this work. There are three main reasons for the Ⅵ damage caused by the earthquake to the houses in the area studied. First, the house foundation is mishandled. Most damaged houses are located in the scarp near the Yangtze River, where part of the houses lie on bedrock foundation and part lie on artificial stone masonry. Therefore, the houses are prone to uneven deformation and cracking. Second, high mountains and deep valleys also have an effect. Due to the amplification of ground motion in abrupt mountain terrain, the houses will suffer stronger seismic action and thus house damage occurs. Third, the houses' structure is defective and the construction quality is unqualified. Most of the damaged houses have cavities in the walls and the constructional columns are missing. The design and construction are not standardized. Hence, the houses are vulnerable to damage caused by earthquakes. Based on the investigation and analysis, four suggestions on the site selection, design, and construction of rural housing have been put forward in this study. These suggestions can provide the basis and reference for the rural construction and government decision-making in the disaster area and other earthquake prone areas. First, the houses should be built in areas which aid earthquake resistant structures. The houses should not be built on towering isolated hills and steep slopes. Second, houses should be built with constructional columns and ring beam structures and with a superior strength of mortar. These are the key measures to ensure that masonry structures do not collapse. Third, the house builders should put emphasis on the foundations design. Finally, the government should train building craftsmen in the rural areas and improve earthquake resistance knowledge.

Key words: Zigui M4.7 earthquake; building damage; sampling statistics; rural buildings; seismic fortification

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0 引言

2014 年 3 月 30 日 0 时 24 分湖北省秭归县发生 $M_{4.7}$ 地震,震中位于秭归县屈原镇(30.92°N , 110.77°E),震源深度 7.5 km,震中烈度 VI 度^[1](图 1)。秭归县、巴东县、兴山县震感强烈。主震发生后,截至 3 月 30 日 8 时 15 分,共发生余震 48 次,最大余震为该日 0 时 33 分发生的 1.5 级地震。本次地震对秭归县郭家坝镇的部分地区造成了一定程度的房屋破坏和财产损失。

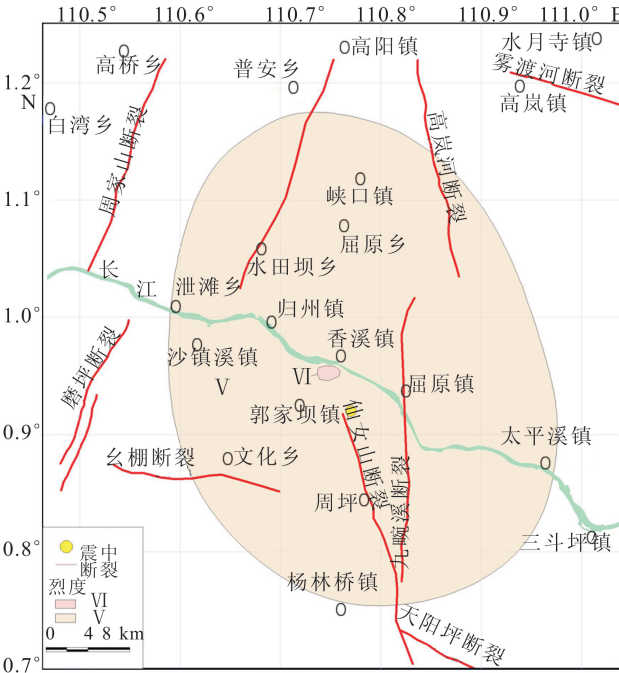


图 1 秭归 M4.7 地震烈度分布图

Fig.1 Seismic intensity distribution of the Zigui M4.7 earthquake

郭家坝镇地处鄂西长江西陵峡畔、秭归县中部,属三峡库区移民大镇,是秭归县版图面积最大、农村人口最多的乡镇。在此次 $M_{4.7}$ 地震中,震损房屋数量较多、险情较重、破坏程度各异。本文对 VI 度区内房屋受损情况进行抽样调查和分析,总结震害类型及原因并提出建议,分析震区房屋的抗震性能,以期今后山区房屋的抗震设计和震害防御工作提供可靠的依据。

1 震区房屋震害统计分析

地震灾区房屋建筑类型以砖混结构和土木结构为主,极少部分为框架结构。此次地震极震区的主要震害特点为土木结构房屋普遍破坏,砖混结构房屋部分破坏,框架结构房屋基本完好。

房屋震害采用抽样调查方式,调查点基本均匀地分布在灾区范围内。根据地震现场灾害损失实地抽样调查结果,对震害损失进行统计。损坏房屋结构分为土木结构和砖混结构两类。调查房屋破坏情况时,按照《地震现场工作 第 4 部分:灾害直接损失评估》(GB/T 18208.4-2011)^[2],将土木结构房屋破坏程度分为毁坏、破坏和基本完好三个破坏等级,将砖混结构房屋破坏分为毁坏、严重破坏、中等破坏、轻微破

坏和基本完好五个破坏等级进行分级评定。

在房屋破坏最严重的郭家坝镇头道河村抽取了 5 个自然村、组,抽样点采取逐栋调查的方式,统计则以行政村为单位。汇总全部调查数据,并给出了 VI 度区内不同结构类型房屋抽样总建筑面积,如图 2 所示。在此基础上,统计得到了各种类型房屋的破坏比,如图 3 所示。

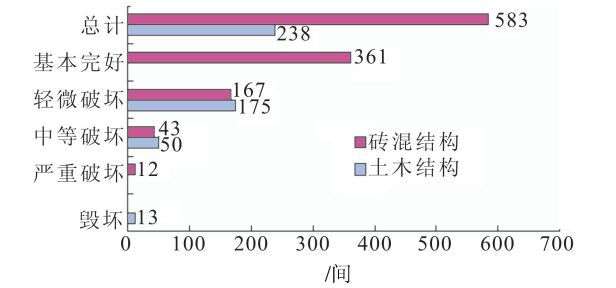


图 2 VI 度区各结构类型房屋破坏抽样汇总图

Fig.2 Sampling statistics of house damage of different types in the area with intensity VI

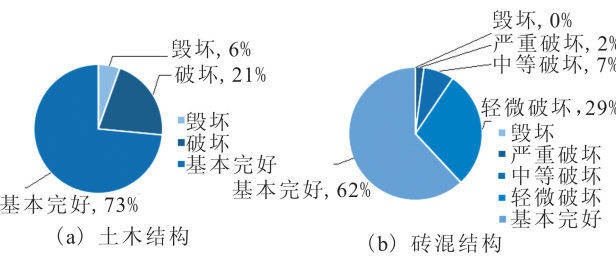


图 3 VI 度区各类房屋建筑破坏比

Fig.3 Damage ratios of buildings of different types in the area with intensity VI

2 典型震害特征及分析

2.1 砖混结构房屋震害特征

此次 $M_{4.7}$ 地震,VI 度区的很多砖混结构房屋表面看不出明显损伤,但内部墙体破坏十分严重。其震害主要表现为墙体开裂、门窗间墙破坏、楼盖破坏等。

(1) 墙体开裂

墙体破坏在此次地震中普遍存在,主要表现为裂缝。在当地民居中,外墙多采用空斗墙,薄弱的墙体因抗剪强度不足而产生斜裂缝,在往复地震作用下将进一步形成“X”型张裂缝(图 4)。

(2) 门窗间墙破坏

在建造农村房屋时,人们片面地追求大开窗,大窗户洞口的设置使墙体的横截面积突然减小。在地震作用下,墙体受到的剪力一旦超过墙体的抗剪强度,就会产生水平裂缝和竖向裂缝甚至交叉裂缝(图 5)。

(3) 楼盖破坏

在鄂西农村民居中,早期建设的房屋多采用预制楼板做楼面。由于预制楼板与墙体连接不牢靠或搁置长度不够,均容易在地震作用下导致震裂(图 6),严重的甚至错位、掉落。



图 4 震中区砖混结构房屋的墙体开裂现象
Fig.4 Walls cracking of brick-concrete buildings in epicenter area



图 5 震中区砖混结构房屋的门窗间墙破坏
Fig.5 Damage of walls between door and window of concrete-brick buildings in epicenter area

2.2 土木结构房屋震害特征

土木结构房屋建造工艺简单,通常就地取材,且造价低廉,在偏远农村自建房屋中比较常见。这类房屋多为土墙承重,屋盖采用木结构。在本次调查的土木结构房屋中,多数年代较为久远。在此次地震中,土木结构房屋的震害主要表

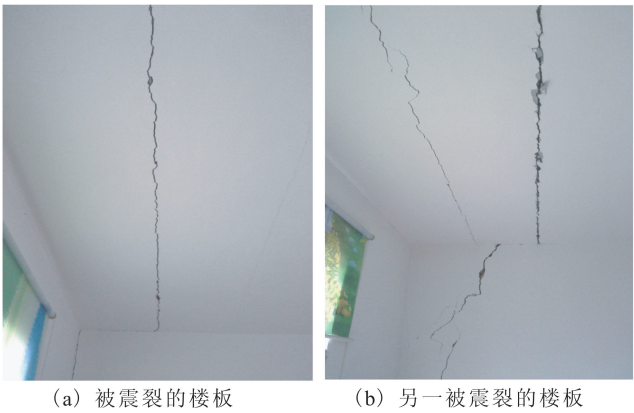


图 6 震中区砖混结构房屋楼盖破坏现象
Fig.6 Damage of floors of concrete-brick buildings in epicenter area
现为瓦片掉落、墙体开裂和坍塌(图 7)等。这种建筑建造工艺粗糙,没有构造措施或构造措施不齐全,墙厚也不符合要求,房屋的整体性较差。农民自建土木结构房屋时,屋面的大梁与纵墙或横墙没有可靠的锚固措施,地震时容易发生墙体倾斜而导致屋架塌落。



图 7 震中区土木结构房屋的震害现象
Fig.7 Damage of civil buildings in epicenter area

3 VI 度区房屋震害成因分析

通过地震灾害现场考察,VI 度异常区形成的主要原因如下:

- (1) 基础处理不当。出现严重破坏房屋均位于公路靠近长江一侧,房屋基础部分处于基岩上,部分为人工石块堆砌体。由于坡形基础处理不当,地震时房屋容易产生不均匀变形,出现开裂现象。
- (2) 高山峡谷地形影响。出现严重破坏房屋均处于沿江山体突出边坡上。地震时由于突出山体对地震动的放大作用,导致房屋受地震作用加强,出现破坏现象。
- (3) 房屋结构有缺陷、施工质量存在问题。出现严重破坏房屋均为 3~4 层砖混房,绝大多数房屋为空斗墙,房屋均无构造柱,部分房屋只在基础、1 层与 2 层间设置圈梁。设计及施工不规范,房屋的整体性差,不利于抗震。

4 结论与建议

2014 年 3 月 30 日湖北省秭归县发生的 M4.7 地震震级不大,却对震中区附近的农村房屋造成了较为严重的破坏,暴露了我国农村房屋建筑抗震能力差的现实情况^[4-5]。为了减少地震给偏远农村地区房屋造成的生命和财产损失,吸取

此次地震灾害的经验教训,本文提出以下几点建议:

- (1) 选择抗震有利地段,避开不利地段
房屋应尽量不选在条状突出的山嘴,高耸孤立的山丘,强风化岩石的陡坡、陡坎,河岸和边坡的边缘等抗震不利地段建造。因为这些不利地段对地震动可能产生放大作用,对房屋抗震不利^[3]。
- (2) 合理设置构造柱和圈梁,提高砂浆的强度
农村房屋建造者必须认识到设置构造柱和圈梁的重要意义,合理设置构造柱和圈梁是保证砌体结构不倒塌的关键措施^[6-7]。同时必须使用足够强度的砂浆,保证墙体牢固的连接。
- (3) 重视房屋地基和基础设计
房屋基础不宜设置在性质截然不同的地基上,同一结构单元不宜部分处于基岩上,部分为人工石块堆砌体。
- (4) 对农村的工匠进行培训,提高其抗震知识水平
应对村镇的工匠进行抗震技术培训并颁发相应的培训合格证,鼓励农民选择有合格证的工匠进行施工建设^[8-9]。

致谢:在 2014 年 3 月 30 日秭归 M4.7 地震震后调查评估过程中,湖北省地震局秦小军副局长进行了认真的指导和帮助,并给出了宝贵的意见和建议。特此致谢!

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