Mid-America Earthquake Center

Project SE-1 Final Report

Inventory of Essential Facilities in Mid-America

Principal Investigators

Steven French, Georgia Institute of Technology

Robert Olshansky, University of Illinois at Urbana-Champaign

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ABSTRACT

The earthquake hazard in mid-America is characterized by large, but infrequent events. As a result, the level of seismic building design and retrofit is generally thought to be lower than in many other seismically active regions, however the exact nature of the building stock is not known. In developing its research agenda the Mid-America Earthquake Center determined that an inventory of essential facilities in the region was part of the foundation needed to support its research efforts. Rather than focus on the entire building stock, we selected essential facilities as the most critical target for this initial investigation. Essential facilities are those facilities that must play an important role in the recovery period following an earthquake. They include hospitals, police and fire stations and schools, which often serve as emergency shelters.

This report summarizes the analysis of 1306 essential facilities for which key structural characteristics were collected through telephone survey contacts. The essential facility inventory was found to be relatively fragile with a large number of unreinforced masonry structures. Schools appear to be the most vulnerable type of facility due to their age, construction types and location with respect to the hazard. The data described here is available to state and local emergency managers over the Internet:
http://mae.ce.uiuc.edu/ResearchPrograms/CRP/BodyEFP.htm or
http://cgis.gatech.edu/Projects/projects.html.

ACKNOWLEDGMENTS

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Purpose

The Mid-America Earthquake Center was formed in the fall of 1997. Due to the relatively infrequent recurrence intervals for damaging earthquakes in Mid-America, the building stock is generally thought to include limited consideration of seismic design. However, the exact characteristics of the building stock are not well documented. The purpose of this project, "Inventory of Essential Facilities in Mid-America" is to provide a better understanding of the characteristics of one key component of the building stock – essential facilities. A better understanding of the characteristics of the existing essential facilities is needed to shape the structural and geotechnical engineering research agenda of the Mid-America Earthquake Center. Analysis of the inventory characteristics will guide the design of laboratory testing of prototypical buildings for risk assessment. In addition to providing guidance to the larger research effort, the inventory data produced by this project will also be directly useful to emergency managers and local officials in Mid-America. Furthermore, the inventory will provide the MAE Center with a better understanding of the age and structural characteristics of the overall building stock in Mid-America. This project (SE-1) is a collaborative effort of researchers at Georgia Institute of Technology and the University of Illinois at Urbana-Champaign.

The facility inventory developed in this project is stored in a geographic information system (GIS) to produce a georeferenced database of essential facilities for the most seismically vulnerable part of Mid-America. The use of the GIS allows the essential facilities inventory to be used with MAE Center hazard maps and with HAZUS loss estimation system developed for the Federal Emergency Management Agency by RMS, Inc. The HAZUS software will be used in later MAE Center risk assessment projects. The inventory database includes information on the size, age, function and basic structural characteristics of a sample of essential facilities. The essential facilities inventory is also compatible with a similar database developed as a part of the MAE Center's Transportation Networks Program (Project SE-3).

This project provides basic information to guide future research endeavors and collaborations, especially among MAE Center researchers. Specifically, the inventory will be useful for Projects SE-5 ("Loss Estimates for Essential Facilities") and SE-6 ("Benefit-Cost of Retrofit for Communities"), and it will provide the key input for Project SE-7 ("Benefit-Cost of Retrofit for Regions"). This inventory data will also be available to state and local emergency management agencies and government officials for estimating losses, determining needs for retrofitting certain facilities, and hazard mitigation.

Definition of Essential Facilities

Essential facilities are those buildings that support functions related to post-earthquake emergency response and disaster recovery. The functionality of these buildings immediately following an earthquake is essential to ensure an effective emergency response. For the purposes of this project, essential facilities will include four types: police stations, fire stations, hospitals, and schools. These facilities are considered "essential" in that they are either emergency service providers or are likely to be used as shelters in the post-earthquake period. This definition is generally consistent with the disaster management literature and matches that used in FEMA's HAZUS software. While other shelters may exist (such as churches and community centers), public schools are the most commonly used type of shelters. They exist in every county and city, are maintained to a specific level of safety and their locations are well known to the local population. Likewise, hospitals must be maintained at a specific level of service in order to be properly certified. Schools and hospitals are also significant because they house especially vulnerable populations.

Furthermore, essential facilities have been selected as the focus for the first coordinated facilities program because of their critical nature, their accessible inventories and more direct criteria for developing retrofit strategies. Rehabilitation strategies for this group of buildings are governed by public health

and safety concerns rather than by economic loss criteria. Subsequent research and implementation programs on industrial and commercial facilities will focus on economic concerns, but essential facilities will be investigated first based on their central role in protecting public health and safety. New findings on the seismic response of structures developed from the Essential Facilities Program should be transferable to these later programs.

Transportation networks also play an important role in emergency management. Although they are not addressed directly in the SE-1 facility inventory, transportation components, especially highways and bridges, are being inventoried in a parallel project (SE-3). Extensive damage to these systems would have national economic ramifications and would seriously impact emergency response and recovery operations in Mid-America. A later study may consider the interaction between essential facilities and transportation systems.

As depicted in FEMA's earthquake hazard maps, the New Madrid Seismic Zone encompasses parts of Missouri, Tennessee, Arkansas, Kentucky, Illinois, Indiana, and Mississippi. The 1994 expected ground motion maps developed by the Applied Technology Council (ATC), identify 141 counties that are expected to experience horizontal acceleration of .10g or greater with 10 percent probability of excedence in 50 years. The SE-1 project includes all 81 counties in the .20g and .15g zones, as well as those 12 counties in the 0.10g zone that have 40,000 or more in population. This final criteria, which expanded the study area from 81 counties to 93 counties, was included because, although these regions may face a lower level of hazard, their density and extensive inventory of essential facilities warranted their inclusion in the study. Thus, the final set includes the cities of Memphis, Tennessee; St. Louis, Missouri; Evansville, Indiana; and Carbondale, Illinois. A map of the study area is shown in Figure 1 and a list of counties included in the study is shown in Table 1.

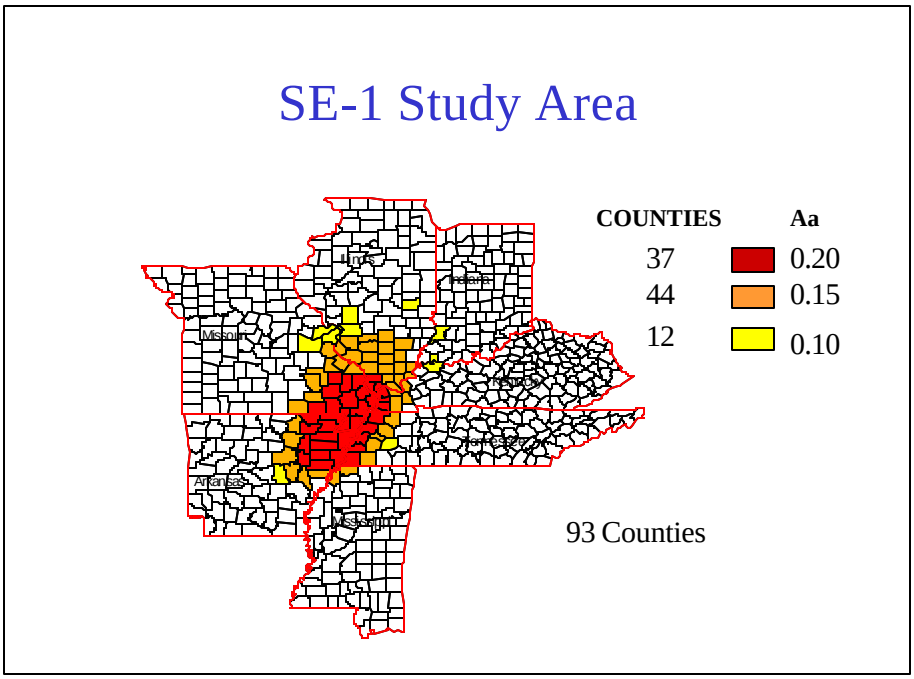

Figure 1. Study Area and Expected Ground Motion

Table 1. Counties in the Study Area

Arkansas	Illinois	Indiana	Kentucky	Mississippi	Missouri	Tennessee
Clay	Alexander	Knox	Ballard	De Soto	Bollinger	Crockett
Craighead	Clinton	Vanderburgh	Carlisle	Tunica	Butler	Dyer
Crittenden	Coles		Fulton		Cape Girardeau	Fayette
Cross	Franklin		Graves		Carter	Gibson
Greene	Gallatin		Henderson		Dunklin	Haywood
Independence	Hamilton		Hickman		Franklin	Lake
Jackson	Hardin		Livingston		Iron	Lauderdale
Lawrence	Jackson		Marshall		Jefferson	Madison
Lee	Jefferson		McCracken		Madison	Obion
Lonoke	Johnson				Mississippi	Shelby
Mississippi	Macoupin				New Madrid	Tipton
Monroe	Madison				Oregon	Weakley
Poinsett	Marion				Pemiscot	
Prairie	Massac				Perry	
Randolph	Monroe				Reynolds	
Sharp	Perry				Ripley	
St. Francis	Pope				Scott	
White	Pulaski				St. Charles	
Woodruff	Randolph				St. Francois	
	Saline				St. Louis	
	St. Clair				St. Louis City	
	Union				St. Genevieve	
	Washington				Stoddard	
	Wayne				Wayne	
	Williamson					

Sampling Methodology and Database Development

Initially, we planned to develop the essential facility inventory by integrating a series of existing databases. Unfortunately, the available secondary data on essential facilities in Mid-America was found to be largely inadequate. However, we were able to compile a comprehensive list of contact names and addresses for facilities in our study area by contacting state agencies, such as hospital authorities, fire marshals and departments of education. The research team with members at the University of Illinois at Urbana-Champaign (UIUC) and the Georgia Institute of Technology (Georgia Tech) gathered facility names, addresses, contact names, and phone numbers from a variety of sources including state and county-level governing bodies and emergency management agencies. Additional inventory data from FEMA's HAZUS database was used to supplement this initial set. The Illinois Emergency Management Agency (IEMA) had previously completed ATC-21 field surveys of facilities in 21 of the 25 Illinois counties in the study area. These facilities were added to the master list. The University of Memphis provided additional data on facilities in Shelby County, Tennessee. After duplications were identified and discarded, the master list contained a total of 5584 entries. This list represents our best estimate of the complete set of essential facilities in the 93-county study area.

From this master list, we then drew a sample to be surveyed using a telephone adaptation of the ATC-21 classification method. (Copies of the survey instruments are included in Appendix A.) This survey method places facilities into one of 17 categories based on structure type and provides other information pertinent to structure performance. Since there were a relatively small number of hospitals, and they may be the most critical components of the post-earthquake emergency response, we included all the hospitals in the study area. We then drew a 20 percent random sample of the essential facilities to survey by telephone. To these we added the 20% of the facilities that had been field

surveyed by IEMA (241 facilities). This procedure produced a sample of 1306 completed surveys. This process is outlined in Figure 2.

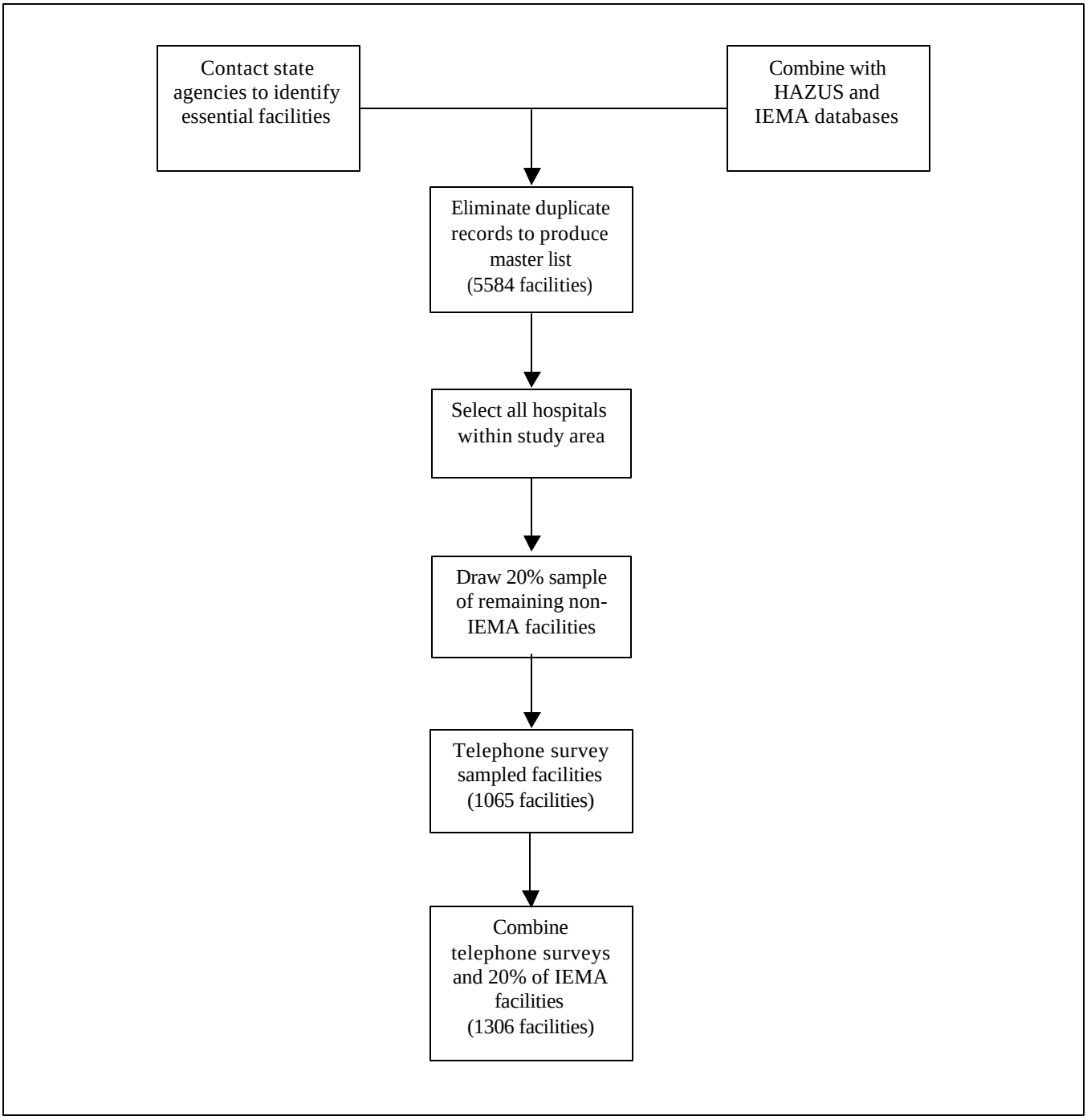

Figure 2. Database Development Process

The telephone surveys were carried out by graduate research assistants at the University of Illinois at Urbana-Champaign and Georgia Institute of Technology. The survey form was first tested in a preliminary test of twelve facilities. This pre-test, together with the suggestions from several MAE Center structural engineers, helped to refine the survey instrument. The final survey forms, one for each facility type, are included in Appendix A. They contain 31 questions investigating the following three levels of information:

Level I data:	facility name, address, contact name, phone/fax number, and e-mail address
Level II data:	information about the use and capacity of the building (e.g. staffing levels, number of floors, square footage, age of building, emergency supplies, past use of the building, etc.)
Level III data:	describes the frame type and structural system of the building

For this survey, the ATC-21 categories for frame types were simplified by collapsing some categories into one. This made the sampling easier for the respondents, while still providing sufficient information on building materials and frame type to support subsequent damage modeling exercises.

The goal was to be able to identify all the basic ATC-21 building types based on the responses to six questions, by employing a “logic tree” method, and to generate a confidence level for each response. This, combined with information concerning the number of floors in the facility, allows us to place each building into the more detailed building categories utilized in the HAZUS risk modeling software.

Data entry software was developed at Georgia Tech specifically for this project. The resulting Visual Basic program placed the survey responses into an Access

database format. This program guided the data entry process through a series of screens that allows both text entries and standardized responses from pull-down menus.

A confidence rating of 1 through 4, 1 being not confident, 4 being very confident, for each structural question was also entered. The software then produces a structural type and overall confidence level based on the entries, thus alleviating the need for analysis before data entry. A diagram explaining this process is included as Appendix B. The resulting data set was analyzed to determine the salient characteristics of the essential facility inventory.

To be useful in subsequent risk analyses, the essential facilities must be spatially located. Once the facilities are located, it is possible to combine them with various types of hazard maps. This is necessary to determine the level of ground motion and other site effects, such as liquefaction, that each facility is likely to experience.

To create a GIS database of essential facilities each facility record was located on a map. As shown in Figure 3, 1306 facilities in the sample were located using three different georeferencing techniques. The 243 facilities (18.6 percent) surveyed by IEMA, were located using latitude and longitude coordinates captured in the field with a GPS unit. This is the most accurate georeferencing method; it is accurate within several feet. Another 363 facilities (27.8 percent) were located by address matching the facilities to TIGER street network files. This method creates fairly accurate locations (within 100 ft.) for those facilities that have street addresses and an available street network. Unfortunately, TIGER street network files with address ranges are not available for the rural parts of the study area. The remaining 700 entries, or 53.6 percent that could not be addressed matched, were located using their zipcode centroid. This method produces locations accurate within one or two miles. This three-stage process created a point location in a GIS for each facility in the database.

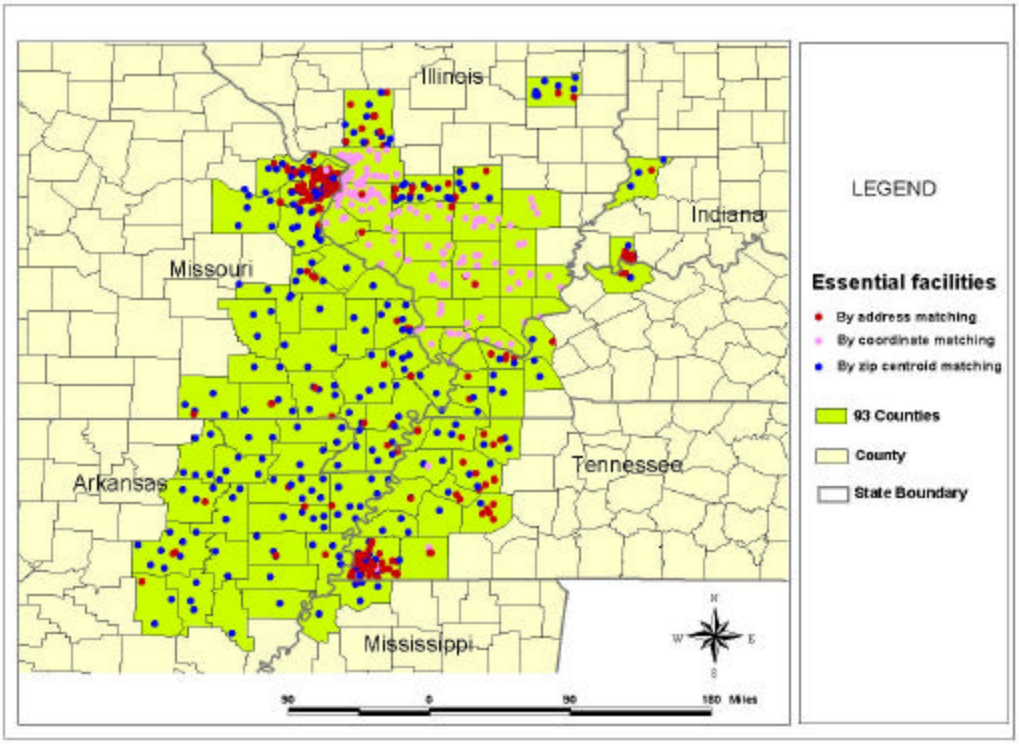

Figure 3. Essential Facilities by Location Method

A database record containing the attributes that describe the facility (e.g. facility type, structure category, etc.) is linked to each georeferenced point. These records can be manipulated using the GIS. Having the structures located in the GIS allows us to assess the numbers of facilities exposed to various levels of ground motion and to various types of ground failure, such as liquefaction.

Figure 4 shows the location of 1306 essential facilities, color coded by facility type (e.g., fire station, police station, school, and hospital). The clustering of facilities, especially schools, in the major urban areas of Memphis and Saint Louis is obvious from this map.

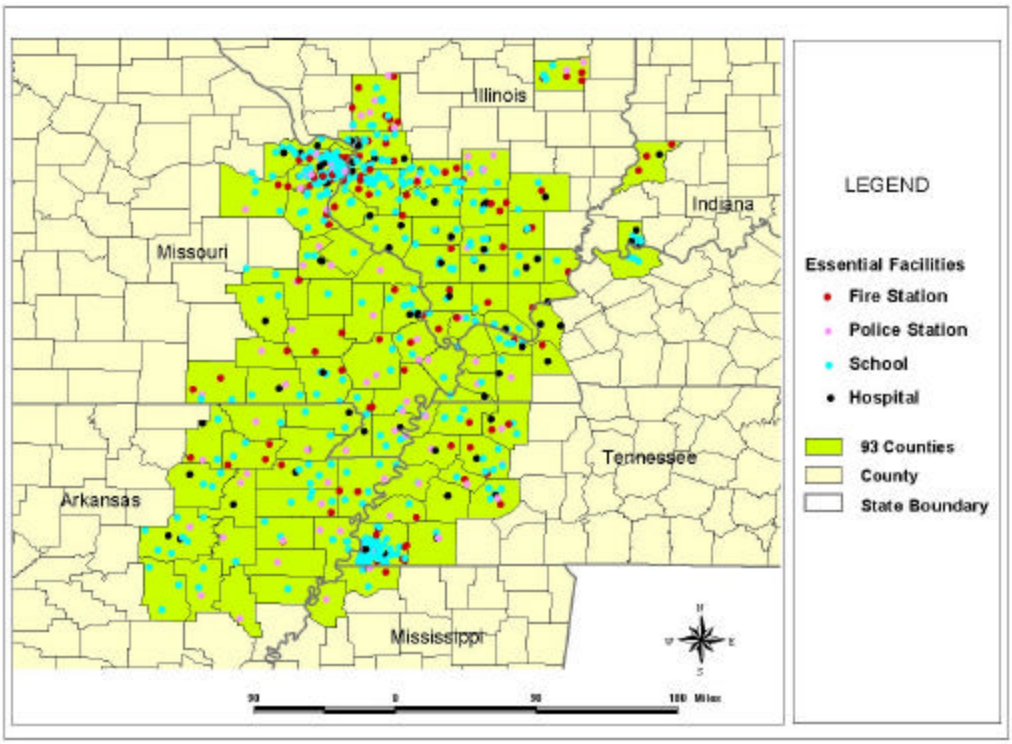

Figure 4. Essential Facilities by Facility Type

Figure 5 shows a more detailed map of essential facilities in downtown Memphis. The different symbols indicate the type of facility: green stars are schools, blue circles are police or fire stations, and red crosses are hospitals. Clicking on any of the markers brings up a table containing the descriptive data for that facility.

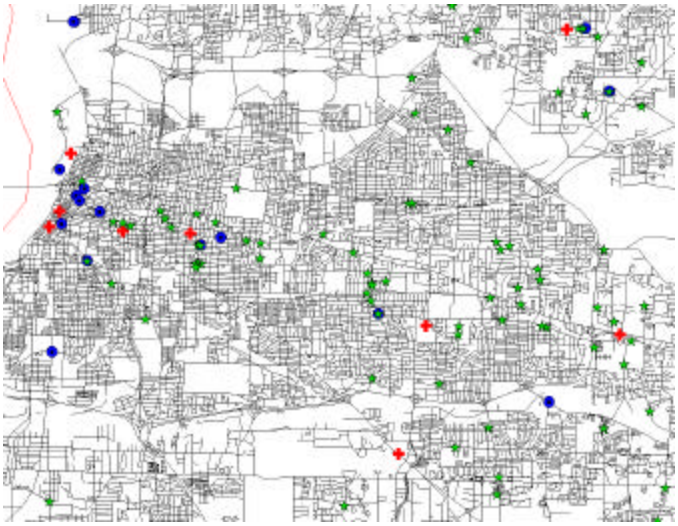

Figure 5. Detailed Facility Location Map in Memphis

Since this inventory was developed based on telephone interviews with building owners and managers, the resulting classification cannot be as accurate as a field inspection of each facility by a trained structural engineer. To indicate how reliable these data are, we developed confidence measures for each facility to indicate the reliability of the classification. Confidence levels were determined based on the responses to four structural questions. The numbers one (1) and zero (0) were used to represent affirmative and negative responses (respectively) to these questions, then the average was taken to arrive at an overall confidence level. Our indicators suggest that we can have a high level of confidence in at least two-thirds of the structural data collected.

The facility type with the lowest overall confidence levels was schools, followed by police stations. These facilities generally did not have highly trained respondents completing the telephone survey. Hospitals often had a professional facility manager or engineer on staff who could provide more accurate structural information.

The frame type that had the lowest confidence level was unreinforced masonry. This can be attributed to the fact that it can be difficult to see the structural elements of a building leading untrained observers to mistake a building with a brick facade for unreinforced masonry. The other frame types generally had very high confidence ratings.

Statistics on year built, square footage, number of stories, frame type, and cross tabulations on various salient characteristics were calculated. In Project SE-5, site visits to essential facilities in two communities were conducted. The results of these field surveys were generally compatible with those produced by the SE-1 telephone survey procedure. This suggests that the procedure produced acceptably reliable information.

Key Characteristics of the Essential Facility Inventory

For statistical analysis, the 1306 database records containing attribute data collected in our telephone survey and the IEMA field inspections were exported into SPSS. A basic statistical analysis of this data reveals the broad outlines of the essential facilities inventory in Mid-America.

As highlighted in Figure 6, a majority of the buildings in the sample were in Illinois (30.9%) and Missouri (26.9%), with Arkansas also accounting for a surprisingly large proportion of the inventory at 21.5 percent. Even with the City of Memphis, Tennessee accounted for a fairly small portion of the inventory (12.5%). The remaining three states each contributed less than 5 percent of the inventory.

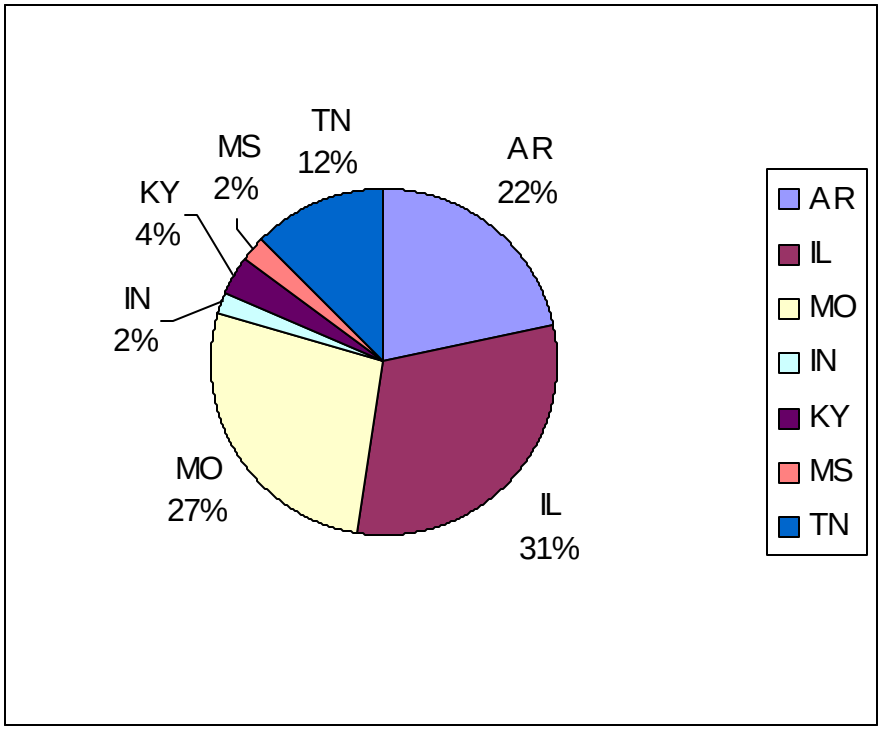

Figure 6. Proportion of Sample by State

Figure 7 depicts the distribution of facilities within our sample by type. Schools dominate the inventory with nearly 58 percent of the observations. There were

216 hospitals (17 percent), 198 fire stations (15 percent) and 137 police stations (10 percent).

The proportions of hospitals and fire stations are roughly equal. Police stations make up the smallest portion of the inventory with just over 10 percent of the facilities. To keep the large number of schools from skewing the overall results, many of the subsequent analyses will be performed separately for each facility type.

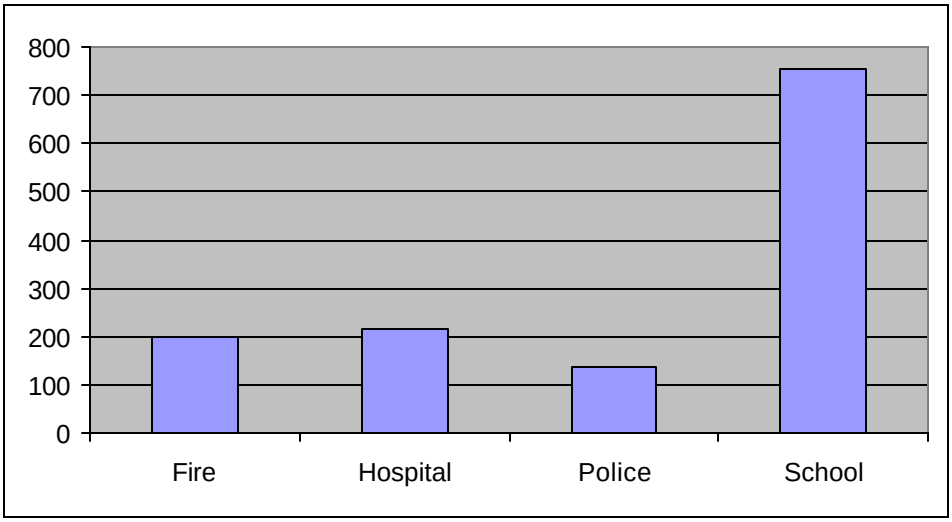

Figure 7. Number of Buildings by Facility Type

Table 2 provides a summary of the number of facilities by type within each state. The mix of facilities varies considerably by state. Due to our strategy of including all hospitals in the sample, they represent a larger proportion of the facility mix in those states that have a smaller number of total observations (Indiana, Kentucky and Mississippi). Other differences are probably attributable to the different levels of urbanization and different timing of historical development among the various states.

Table 2. Number of Facilities by Type and State

State	Fire	Hospital	Police	Schools	Total
Arkansas	24	26	24	207	**281 (21.5%)**
Illinois	67	83	37	217	**404 (30.9%)**
Indiana	4	12	3	12	**31 (2.4%)**
Kentucky	4	18	6	18	**46 (3.5%)**
Missouri	65	51	48	187	**351 (26.9%)**
Mississippi	6	8	5	11	**30 (2.3%)**
Tennessee	28	18	14	103	**163 (12.5%)**
TOTAL	**198 (15.2%)**	**216 (16.5%)**	**137 (10.5%)**	**755 (57.8%)**	**1306 (100%)**

Probably the single most important kind of information collected in this inventory is the structural type of the facilities. The structural characteristics of the building are the most critical factors in determining its seismic response in the event of an earthquake. Structural type is also critical in determining the type of mitigation that may be most effective for a particular building. In 1986 the Applied Technology Council developed a visual screening technique for evaluating the seismic resistance of buildings based on a "sidewalk survey." The ATC methodology places a building into one of seventeen categories based on its frame type (Applied Technology Council, 1986). Both our telephone surveys and the IEMA field survey categorized structures based the system developed by the Applied Technology Council, better known as ATC-21.

A similar classification scheme was modified for use in the HAZUS loss estimation software developed for the Federal Emergency Management Agency (National Institute of Building Sciences, 1997). The HAZUS Technical manual provides fragility curves for each structural type that relates ground motion to building damage.

Table 3. Number of Facilities by Structure Type

Structure Type	Number	Percent
C1 – Concrete	9	0.7
C2 – Concrete	78	6.0
C3 – Concrete Frame	83	6.4
MH – Mobile Home	17	1.3
PC1 – Precast Concrete	10	0.8
PC2 – Precast Concrete	5	0.4
RM1 - Reinforced Masonry	72	5.5
RM2 – Reinforced Masonry	30	2.3
S1 – Steel Frame	54	4.1
S2 – Steel Frame	21	1.6
S3 – Prefabricated Steel	91	7.0
S4 – Steel Frame	22	1.7
S5 – Steel Frame	163	12.5
URM – Unreinforced Masonry	428	32.8
W1 – Wood Frame	81	6.2
W2 – Wood Frame	43	3.3
Unknown	99	7.6
Total	**1306**	**100**

Table 3 shows the categorization scheme and the number of facilities in each structural class. Overall, the most common type of structure was unreinforced masonry, comprising nearly one-third of the total sample. This highlights the extreme vulnerability of Mid-America to even a moderate earthquake, since this is the most fragile structure type. Concrete and reinforced masonry structures accounted for another 20 percent of the inventory. This suggests that a significant portion of the MAE Center's experimental and analytical research should be directed toward masonry structures, since they account for a majority of the essential facility inventory.

Steel frame structures of all types accounted for nearly 27 percent of the inventory. Generally, steel frame buildings can be expected to behave well under earthquake loadings. However, about a quarter of the steel frame buildings identified in this study were the more fragile prefabricated steel buildings.

Wood frame, mobile homes and precast concrete buildings accounted for a relatively small percentage of the overall inventory. While these structure types can be expected to be more common in the general building stock, they are not widely used for essential facilities.

For cross tabulation purposes we simplified the seventeen ATC structure classes into eight general categories. Table 4 shows how the distribution of structure types varies considerably by state. This analysis suggests that the inventories in some states are more vulnerable than others.

Table 4. Structure Type by State
(Column Percentages)

	AR	IL	IN	KY	MO	MS	TN	Total
Concrete	20 7.1%	42 10.4%	5 16.1%	18 39.1%	43 12.3%	2 6.7%	40 24.5%	170 13.0%
Mobile Home	8 2.8%	6 1.5%		1 2.2%	1 0.3%	1 3.3%		17 1.3%
Precast Concrete	3 1.1%	3 0.7%	1 3.2%	2 4.3%	4 1.1%		2 1.2%	15 1.1%
Reinforced Masonry	17 6.0%	19 4.7%		3 6.5%	49 14.0%	5 16.7%	9 5.5%	102 7.8%
Steel Frame	110 39.1%	73 18.1%	14 45.2%	11 23.9%	96 27.4%	15 50.0%	32 19.6%	351 26.9%
Unknown	11 3.9%	8 2.0%	2 6.5%	3 6.5%	48 13.7%	2 6.7%	25 15.3%	99 7.6%
Unreinforced Masonry	68 24.2%	214 53.0%	3 9.7%	7 15.2%	83 23.6%	3 10.0%	50 30.7%	428 32.8%
Wood Frame	44 15.7%	39 9.7%	6 19.4%	1 2.2%	27 7.7%	2 6.7%	5 3.1%	124 9.5%
Total	281 100.0%	404 100.0%	31 100.0%	46 100.0%	351 100.0%	30 100.0%	163 100.0%	1306 100.0%

In Illinois and Tennessee unreinforced masonry facilities were the most common structure type. They were the second most common type in Arkansas, Missouri and Mississippi. Unreinforced masonry buildings are particularly vulnerable to earthquake ground motion. The states with large numbers of essential facilities

of unreinforced masonry construction can be expected to have significant problems responding to a damaging earthquake. The fact that more than half of the inventory in Illinois consisted of unreinforced masonry was particularly troubling. Since this classification was based on actual field inspections by IEMA personnel, we have a high degree of confidence in the accuracy of these observations. Indiana, Mississippi and Kentucky had relatively small proportions of unreinforced masonry facilities.

Steel frame buildings were the most common in Arkansas, Indiana, Missouri and Mississippi. These buildings can be expected to perform relatively well in the event of an earthquake. In Kentucky concrete frame buildings were the most common type, followed by steel frame.

Figure 8 shows the percentage of frame types for each kind of facility. The distribution of frame types differed markedly by facility type. While unreinforced masonry, steel frame and concrete were the most common across all facility types, their relative importance varied considerably. A more detailed breakdown of the number of buildings of each structure type and kind of facility is

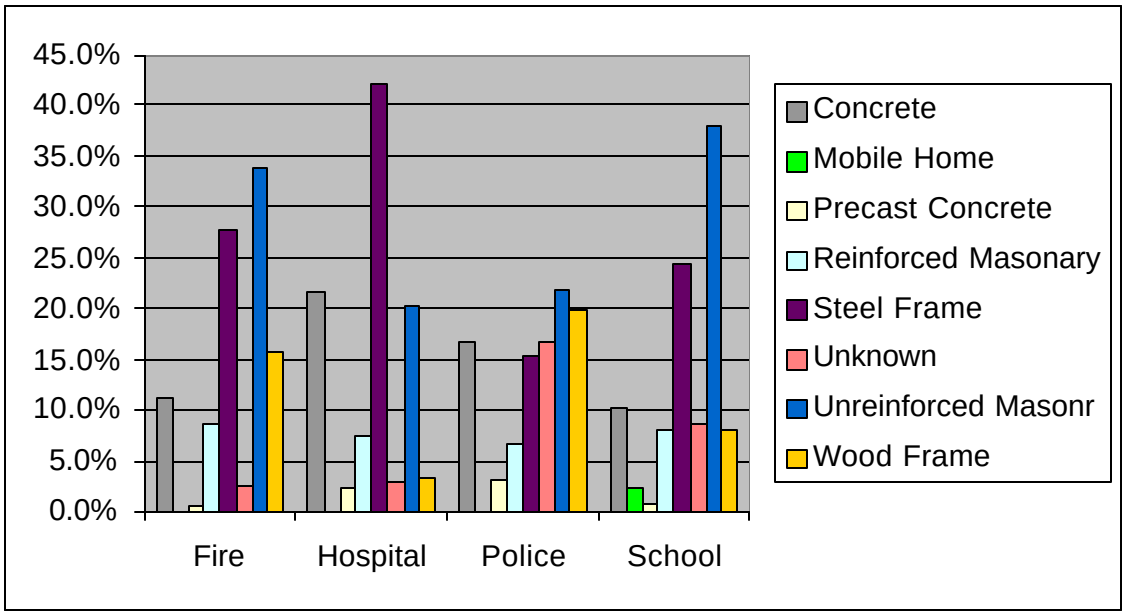

Figure 8. Structure Type by Facility Type

depicted in Table 5. More than 40 percent of the hospitals surveyed had steel frames. This percentage was higher than for any other type of facility because hospitals tend to be larger and were more often multi-story buildings. Concrete was the next most common frame type among the hospitals. However twenty percent of the hospitals were found to be unreinforced masonry.

Table 5. Structure Type by Facility Type
(Column Percentages)

	Fire	Hospital	Police	School	Total
Concrete	22 11.1%	47 21.8%	23 16.8%	78 10.3%	170 13.0%
Mobile Home	0	0	0	17 2.3%	17 1.3%
Precast Concrete	1 0.5%	5 2.3%	4 2.9%	5 0.7%	15 1.1%
Reinforced Masonry	17 8.6%	16 7.4%	9 6.6%	60 7.9%	102 7.8%
Steel Frame	55 27.8%	91 42.1%	21 15.3%	184 24.4%	351 26.9%
Unknown	5 2.5%	6 2.8%	23 16.8%	65 8.6%	99 7.6%
Unreinforced Masonry	67 33.8%	44 20.4%	30 21.9%	287 38.0%	428 32.8%
Wood Frame	31 15.7%	7 3.2%	27 19.7%	59 7.8%	124 9.5%
Total	198 100.0%	216 100.0%	137 100.0%	755 100.0%	1306 100.0%

The largest proportion of school buildings (38 percent) was constructed of unreinforced masonry. This suggests that many of these facilities will not be available to serve as shelters in the emergency response period following a strong earthquake. Furthermore, the large number of unreinforced school buildings represents a significant life safety threat to the children of Mid-America. Steel frame buildings were the next most common structure type, comprising nearly a quarter of the schools.

Police and fire stations displayed a greater mix of structure types, including a significant number of wood frame buildings as well as steel frame, concrete and unreinforced masonry. It is noteworthy that just over one-third of the fire stations are unreinforced masonry. If these structures fail, many local communities may have trouble providing basic emergency response services immediately following an earthquake.

Of the 1306 facilities surveyed, the respondents were able to estimate the age (year built) of 97 percent of the buildings. Of these, the average year built was 1962, with a standard deviation of 23. The median year built was 1965, very close to the mean year built.

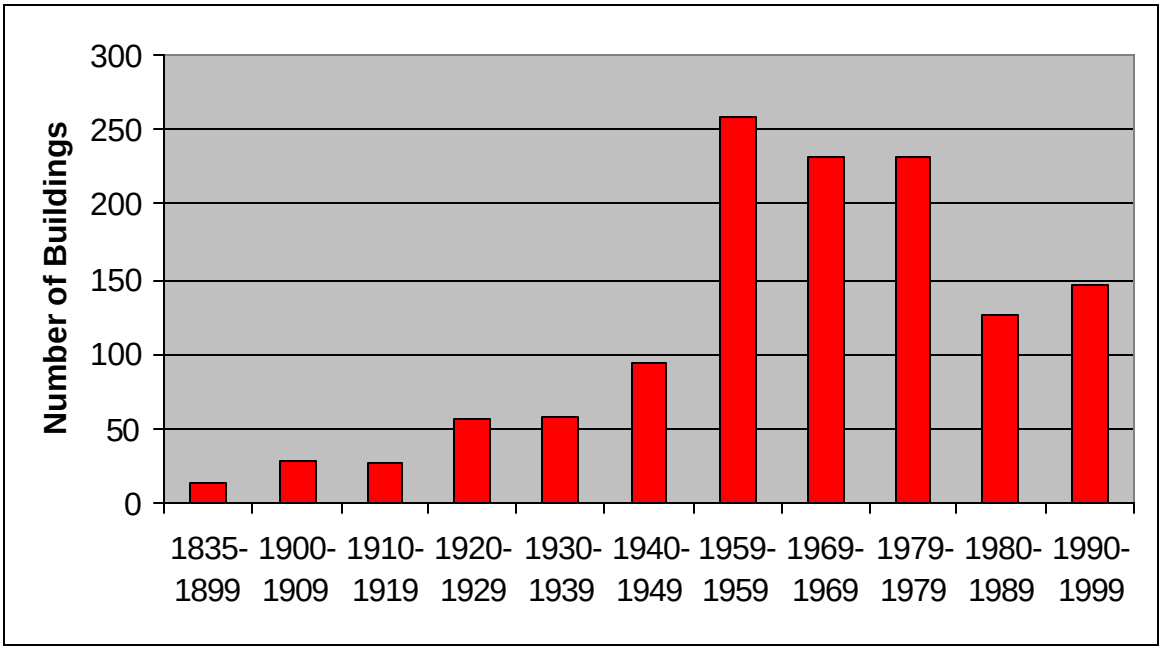

Figure 9. Age Distribution of the Facility Inventory

Our survey found that the age of the building and its use are often related to the frame type. We can begin to see a relationship between age and structure type in Table 6 below. For example, in the time period before 1940 more than half of the structures were unreinforced masonry. This proportion declined steadily to

the present, where this type of construction accounts for only 15 percent of the facilities. The proportion of reinforced masonry has also declined steadily to less than 10 percent in the most recent time period. These two structure types have largely been replaced by steel frame structures. While we found few steel frame structures before 1940, 43 percent of the facilities built since 1980 utilized steel frames.

Table 6. Structure Type by Age
(column percentages)

	1835 1899	1900-1919	1920-1939	1940-1959	1960-1979	1980-1999	Total
Concrete	2 11.8%	1 2.2%	12 10.5%	73 20.7%	59 12.7%	21 7.7%	168 13.3%
Mobile Home	0	0	0	0	2 .4%	10 3.7%	12 .9%
Precast Concrete	0	0	1 .9%	3 .9%	8 1.7%	2 3.7%	14 1.1%
Reinforced Masonry	4 23.5%	7 15.2%	7 6.1%	19 5.4%	37 8.0%	26 9.6%	100 7.9%
Steel Frame	0	4 8.7%	5 4.4%	52 14.8%	169 36.3%	118 43.4%	348 27.5%
Wood Frame	2 11.8%	3 6.5%	14 12.3%	34 9.7%	34 7.3%	34 12.5%	121 9.6%
Unreinforced Masonry	8 47.1%	30 65.2%	64 56.1%	145 41.2%	127 27.3%	41 15.1%	415 32.8%
Unknown	1 5.9%	1 2.2%	11 9.6%	26 7.4%	29 6.2%	20 7.4%	88 7.0%
Total	17 1.3%	46 3.6%	114 9.0%	352 27.8%	465 36.7%	272 21.5%	1266 100%

As shown in Table 7 over half of the facilities in our sample were constructed after 1960. However, age varies considerably by type: schools were older than any of the other facility types. Roughly two-thirds of the fire stations, police stations and hospitals had been constructed since 1960, whereas only about half schools were that new. Less than 20 percent of the schools had been constructed in the past two decades. Nearly 15 percent of the schools were constructed before 1940. Given that the stock of schools in our sample are older

than the other facilities; and given that unreinforced masonry is the most prevalent frame type found in schools, we can expect that a high percent of schools will sustain significant damage in the event of a severe earthquake.

Table 7. Age by Facility Type

(Row percentages)

	1835 1899	1900- 1919	1920- 1939	1940- 1959	1960- 1979	1980- 1999	Total
Fire	0	3 1.6%	10 5.2%	45 23.6%	70 36.6%	63 33.0%	191 100%
Hospital	2 .9%	7 3.3%	17 8.0%	54 25.4%	83 39.0%	50 23.5%	213 100%
Police	3 2.3%	4 3.1%	11 8.5%	30 23.35	50 38.8%	31 24.0%	129 100%
School	12 1.6%	32 4.45	76 10.4%	223 30.4%	262 35.7%	128 17.5%	733 100%
Total	17 1.3%	46 3.6%	114 9.0%	352 27.8%	465 36.7%	272 21.5%	1266 100%

The age distribution by state is similar across the study area. However, the structures in Mississippi are somewhat newer than those in the other states.

Table 8. Structure Height by Facility Type

(column percentages)

Number of Stories		TYPE				Total
		Fire	Hospital	Police	School	
1	Count %	158 79.8%	83 38.4%	94 68.6%	527 69.8%	862 66.0%
2	Count %	38 19.2%	39 18.1%	36 26.3%	157 20.8%	270 20.7%
3~5	Count %	2 1.0%	69 31.9%	6 4.4%	71 9.4%	148 11.3%
Above 6	Count %	0 0%	25 11.6%	1 .7%	0 0%	26 2.0%
Total	Count %	198 100.0%	216 100.0%	137 100.0%	755 100.0%	1306 100.0%

As shown in Table 8, two-thirds of the facilities surveyed were one-story buildings. The vast majority (86.7 percent) of total buildings were one or two-story buildings. Hospitals dominated the multi-story buildings.

We were interested in the amount of retrofitting that has taken place in Mid-America. Table 9 reveals that very few buildings had been retrofitted. Only 6.1 percent of the buildings were thought to have been retrofitted. This is an especially small percentage considering that essential facilities are generally the first buildings to be retrofitted due to their special role in protecting public health and safety. This suggests there is a strong need for cost-effective retrofit techniques in Mid-America.

Table 9. Retrofitted Buildings

	Don't know	No	Probably No	Probably Yes	Yes	N/A	Total
Count	200	496	186	13	67	344	1306
Percent	15.3%	38.0%	14.2%	1.0%	5.1%	26.3%	100%

The analysis suggests that Mid-America has a relatively vulnerable inventory of essential facilities. There are large numbers of unreinforced masonry buildings, especially among the schools. Very few of the buildings have received any seismic retrofit improvements.

Hazard Exposure of Essential Facilities

Since the essential facility inventory has been georeferenced, it is possible to overlay the facility inventory on to various types of hazard maps. Figure 10 combines the essential facility inventory with a map of expected ground motion. This analysis reveals that the area with an expected ground motion of .15g contains the largest numbers of essential facilities in our study area.

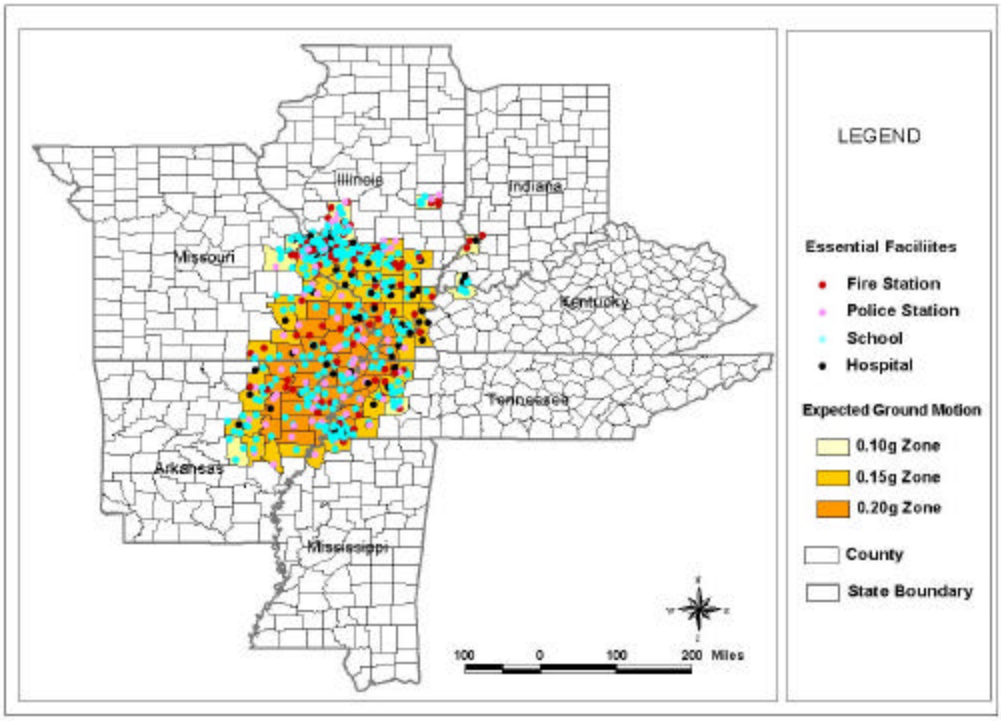

Figure 10. Expected Ground Motion and Essential Facilities

Table 10 shows the number of facilities exposed to each level of expected ground motion. It shows that the schools and police stations are slightly more likely to be located within the area of greatest expected ground motion. Relatively few hospitals are located in the .2g area, probably due to its predominantly rural nature.

Table 10. Expected Ground Motion Exposure by Facility Type

(column percentages)

	Fire		Hospital		Police		School		Total	
.10g	62	31.3%	88	40.7%	43	31.4%	189	25.0%	382	29.2%
.15g	79	39.9%	77	35.6%	51	37.2%	301	39.9%	508	38.9%
.20g	57	28.8%	51	23.6%	43	31.4%	265	35.1%	416	31.9%
Total	198	100.0%	216	100.0%	137	100.0%	755	100.0%	1306	100.0%

Figure 10 shows the facility inventory overlaid upon the liquefaction map developed by the CUSEC State geologists. It divides the area into areas of high and low probability of experiencing liquefaction in the event of an earthquake. The large number of essential facilities in probable liquefaction zones in Arkansas and southeastern Missouri is striking.

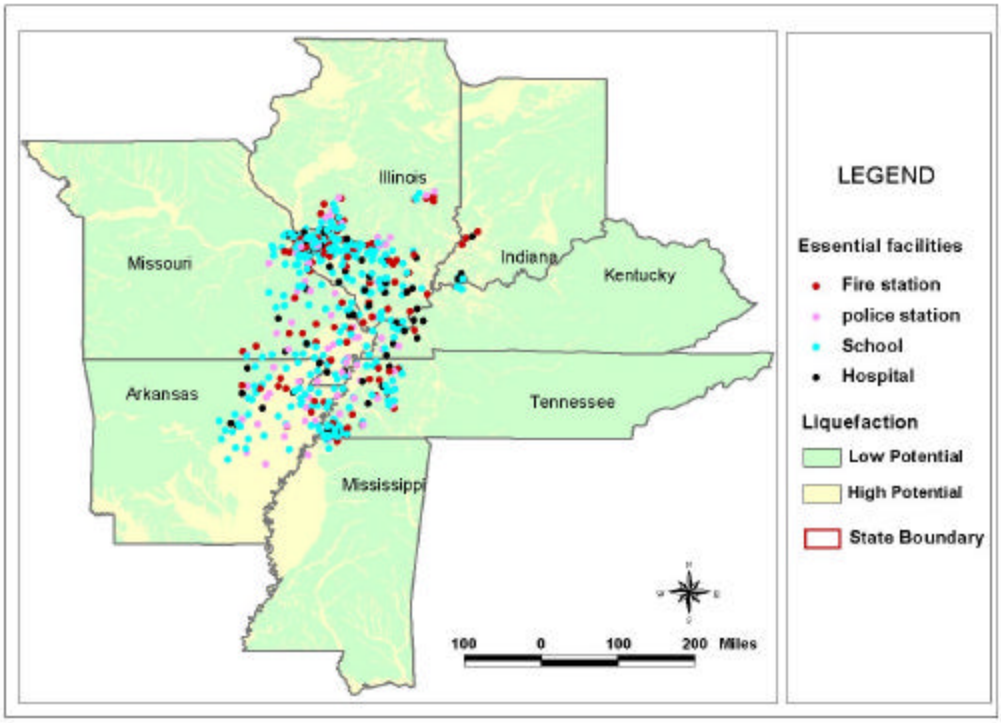

Figure 11. Liquefaction and Essential Facilities

As shown in Table 11, 18 percent of the essential facilities was located in a high liquefaction area for expected ground motions of 0.20g. These facilities are extremely vulnerable. They include 154 schools, 31 fire station, 27 police station, and 25 hospitals. Given the level of hazard exposure, these facilities may warrant special attention as the state and local governments consider mitigation action plans.

Table 11. Exposure to Ground Motion and Liquefaction

Liquefaction	PGA	Fire		Hospital		Police		School		Total	
Low	0.1 g	48	24%	25	12%	33	24%	111	15%	217	17%
	1.5 g	60	30%	57	26%	40	29%	219	29%	376	29%
	2.0 g	26	13%	26	12%	16	12%	111	15%	179	14%
High	0.1 g	14	7%	63	29%	10	7%	78	10%	165	13%
	1.5 g	19	10%	20	9%	11	8%	82	11%	132	10%
	2.0 g	31	16%	25	12%	27	20%	154	20%	237	18%
Total		198	100%	216	100%	137	100%	755	100%	1306	100%

Conclusions

This inventory indicates that the essential facilities in Mid-America are relatively vulnerable due to the large proportion of masonry buildings. Schools appear to be particularly vulnerable suggesting there may be significant problems providing post-earthquake shelter. Hospitals are more likely to have steel frames, the best of the structural classes. It is important to note that our survey did not address non-structural issues, which may severely compromise the hospital's ability to function in the post-earthquake period.

The data developed in this project has and will continue to be used by other MAE Center researchers. It should be useful to state and local emergency managers. To aid in the dissemination of this inventory, it is available for downloading from a web site (http://cgis.gatech.edu/Projects/projects.html). The data are available in tabular form as Excel spreadsheets for individual states and the entire study area. For those with GIS capability, a georeferenced version of the data set is also available as a set of ArcView shapefiles, again for individual states as well as the entire study area.

References

Applied Technology Council. 1986. *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, ATC-21*. Redwood City, CA: Applied Technology Council.

National Institute of Building Sciences. 1997. *HAZUS Technical Manual*. Washington, D.C.: Federal Emergency Management Agency.

Appendix A

TELEPHONE SURVEY FORM: SE-1 ESSENTIAL FACILITIES SURVEY: FIRE STATIONS

Facility: _____

Contact: _____ Position/Title: _____

Phone: _____

Address: _____

_____

Call Record:		
date/time:	person contacted:	comment:

Hello, my name is _____. I am calling from Georgia Tech in Atlanta, Ga. We are working on behalf of the Mid-America Earthquake Center conducting a survey of essential facilities in the New Madrid Fault Zone. Could you, or could someone there, answer a few questions for us about your building?

Q-1. What is the street address for this fire station?

_____

Q-2. Who is the best person to contact about the fire station's physical structure?

_____ position/title: _____

Q-3. What is the fax number for this station? _____

Q-4a. Does the fire station stand by itself or is it connected to another building?

STAND ALONE CONNECTED

(if standing alone go on to question Q-5)

Q-4b. What is the other building used for?

_____

Q-4c. Was the other building built at the same time as the fire station? YES NO

If not, do you know when it was built?

_____

Q-4d. Is this an estimate? YES NO

Q-4e. How are the two buildings connected?

_____

Q-5. How many floors does the fire station have? _____

Q-6a. What year was the station built? It is okay to estimate the year.

_____

Q-6b. Is this an estimate? YES NO

Q-7a. How many firefighters are stationed at this facility?
Daytime: _____ Night: _____

Q-7b. How many firefighters are on call? _____

Q-7c. Is this a volunteer fire department? YES NO

Q-8a. How many vehicles are normally parked inside the station?

_____

Q-8b. How many garage door openings does the station have?

_____

Q-10a. Is the building basically a box or rectangle? BOX RECTANGLE
(if YES go on to question Q-11) NO DON'T KNOW

Q-10b. Is the building "T" or "L" shaped? "T" "L" NEITHER
(if "T" or "L" go on to question Q-11)

Q-10c. Describe the shape of the building as if you were seeing it from above.

sketch

_____

_____

_____

Q-11. Does this station have an emergency power generator? YES NO

Q-13a. Does the station have any meeting rooms? YES NO DON'T KNOW

Q-13b. (if 'YES') About how many people does the meeting room hold comfortably?

_____

Q-14. Does the station have a kitchen? YES NO DON'T KNOW

Q-15a. Does the station have a radio transmitter tower? YES NO
(If NO go on to question Q-17)

Q-15b. How tall is the tower? _____

Q-15c. Is the tower on top of the station? YES NO

Q-15d. (If "NO") How far away from the station is it? _____

Q-17a. What is the square footage of the building? _____

Q-17b. Is this an estimate? YES NO

Q-18. Does the building have a basement? YES NO

Q-19a. Has this building always been used as a fire station? YES NO DON'T KNOW

Q19b. (if "NO") What was it used for in the past?
Original use: _____
Other uses: _____
_____

I have just a few more questions about the building.

Q-20. Is this building a mobile home or trailer? YES NO

(If YES go on to question Q-26)

Q-21. Is the frame of the building wood, steel, concrete or brick?

WOOD STEEL CONCRETE BRICK UNKNOWN

(If WOOD go to question Q-22
STEEL go to question Q-23,
CONCRETE go to question Q-24,
BRICK go to Q-25, UNKNOWN go to Q-26)

Q-22a. Is the frame covered by masonry? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-22b. (if "YES") Is it reinforced masonry? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Go on to question Q-26.

Q-23a. Is the building a 'pre-fab' steel structure? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-23b. What are the exterior walls made out of? _____

Q-23c. What are the interior walls made out of? _____

Q-23d. Is the frame braced or is it a moment resisting frame?

BRACED MOMENT NEITHER DON'T KNOW

Go on to question Q-26.

Q-24a. Is the building built with pre-cast tilt-up walls? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

(If YES go on to question Q-26)

Q-24b. Is the building built with a pre-cast frame? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

(If YES go on to question Q-26)

Q-24c. Is it a moment resisting frame? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-24d. What are the in-fill walls made of? UNREINFORCED MASONRY
OTHER: _____

Go on to question Q-26.

Q-25a. Is the masonry reinforced? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-25b. (If "NO") What is the diaphragm made of? WOOD STEEL CONCRETE DON'T KNOW

Q-26a. Viewed from the front, is the building symmetrical or asymmetrical in structure?

SYMMETRICAL ASYMMETRICAL DON'T KNOW

Q-26b. If 'asymmetrical' describe: _____

Q-27a. Is the building elevation even across the roof?

REGULAR IRREGULAR DON'T KNOW

Q-27b. If 'irregular' describe: _____

Q-28a. Has the building been seismically retrofitted? YES PRETTY SURE DON'T THINK SO
NO DON'T KNOW

(If NO go on to END)

Q-28b. When was the retrofitting done? _____

Q-28c. Is this an estimate? YES NO

Q-28d. What was done? _____

_____

_____

END

Q-29. Does this building have any other special properties that we have not asked you about?

_____

_____

_____

Q-30. Do you have a photograph of the building that you could send to us? YES NO

If YES then provide address.

Q-31. Would you like to be kept informed of the progress of this project? YES NO

Thank you for helping us with this survey. Let me give you a number to call in case you have any questions about the survey. Our number here is 404.385.0906; and my name is _____.

Post-survey Evaluation

Respondent's Attitude: HELPFUL OBLIGING IMPATIENT UNHELPFUL

Gut Instinct' Confidence Level:
KNOWLEDGEABLE TRYING BUT NOT VERY KNOWLEDGEABLE
NOT TRYING-NOT KNOWLEDGEABLE

TELEPHONE SURVEY FORM: SE-1 ESSENTIAL FACILITIES SURVEY: POLICE STATIONS

Facility: _____

Contact: _____ Position/Title: _____

Phone: _____

Address: _____

_____

Call Record:		
date/time:	person contacted:	comment:

Hello, my name is _____. I am calling from Georgia Tech in Atlanta, Ga. We are working on behalf of the Mid-America Earthquake Center conducting a survey of essential facilities in the New Madrid Fault Zone. Could you, or could someone there, answer a few questions for us about your building?

Q-1. What is the street address for this police station?

_____

Q-2. Who is the best person to contact about the station's physical structure?

_____ position/title: _____

Q-3. What is the fax number for this station? _____

Q-4a. Does the police station stand by itself or is it connected to another building?

STAND ALONE CONNECTED

(if standing alone go on to question Q-5)

Q-4b. What is the other building used for?

_____

Q-4c. Was the other building built at the same time as the police station? YES NO

If not, do you know when it was built? _____

Q-4d. Is this an estimate? YES NO

Q-4e. How are the two buildings connected?

_____

Q-5. How many floors does the police station have?

Q-6a. What year was the station built? It is okay to estimate the year.

_____

Q-6b. Is this an estimate? YES NO

Q-7a. How many personnel are normally in the building?
Daytime: _____ Night: _____

Q-7b. How many officers are on call? _____

Q-9c. Does the station have a garage facility? YES NO DON'T KNOW

Q-9a. How many vehicles does it hold? _____

Q-10a. Is the building basically a box or rectangle? BOX RECTANGLE
(if YES go on to question Q-11) NO DON'T KNOW

Q-10b. Is the building "T" or "L" shaped? "T" "L" NEITHER
(if "T" or "L" go on to question Q-11)

Q-10c. Describe the shape of the building as if you were seeing it from above.

sketch

_____

_____

_____

Q-11. Does this station have an emergency power generator? YES NO DON'T KNOW

Q-13a. Does the station have any meeting rooms? YES NO DON'T KNOW

Q-13b. (if 'YES') About how many people does the meeting room hold comfortably?
_____

Q-14. Does the station have a kitchen? YES NO DON'T KNOW

Q-15a. Does the station have a radio transmitter tower? YES NO
(If NO go on to question Q-17)

Q-15b. How tall is the tower? _____

Q-15c. Is the tower on top of the station? YES NO

Q-15d. (If "NO") How far away from the station is it? _____

Q-17a. What is the square footage of the building? _____

Q-17b. Is this an estimate? YES NO

Q-18. Does the building have a basement? YES NO

Q-19a. Has this building always been used as a police station? YES NO DON'T KNOW

Q19b. (if "NO") What was it used for in the past?
Original use: _____
Other uses: _____
_____

I have just a few more questions about the building.

Q-20. Is this building a mobile home or trailer? YES NO

(If YES go on to question Q-26)

Q-21. Is the frame of the building wood, steel, concrete or brick?

WOOD STEEL CONCRETE BRICK UNKNOWN

(If WOOD go to question Q-22
STEEL go to question Q-23,
CONCRETE go to question Q-24,
BRICK go to Q-25, UNKNOWN go to Q-26)

Q-22a. Is the frame covered by masonry? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-22b. (if "YES") Is it reinforced masonry? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Go on to question Q-26.

Q-23a. Is the building a 'pre-fab' steel structure? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-23b. What are the exterior walls made out of? _____

Q-23c. What are the interior walls made out of? _____

Q-23d. Is the frame braced or is it a moment resisting frame?

BRACED MOMENT NEITHER DON'T KNOW

Go on to question Q-26.

Q-24a. Is the building built with pre-cast tilt-up walls? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

(If YES go on to question Q-26)

Q-24b. Is the building built with a pre-cast frame? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

(If YES go on to question Q-26)

Q-24c. Is it a moment resisting frame? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-24d. What are the in-fill walls made of? UNREINFORCED MASONRY
OTHER: _____

Go on to question Q-26.

Q-25a. Is the masonry reinforced? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-25b. (If "NO") What is the diaphragm made of? WOOD STEEL CONCRETE DON'T KNOW

Q-26a. Viewed from the front, is the building symmetrical or asymmetrical in structure?

SYMMETRICAL ASYMMETRICAL DON'T KNOW

Q-26b. If 'asymmetrical' describe: _____

Q-27a. Is the building elevation even across the roof?

REGULAR IRREGULAR DON'T KNOW

Q-27b. If 'irregular' describe: _____

Q-28a. Has the building been seismically retrofitted? YES PRETTY SURE DON'T THINK SO
NO DON'T KNOW

(If NO go on to END)

Q-28b. When was the retrofitting done? _____

Q-28c. Is this an estimate? YES NO

Q-28d. What was done? _____

_____

_____

END

Q-29. Does this building have any other special properties that we have not asked you about?

_____

_____

_____

Q-30. Do you have a photograph of the building that you could send to us? YES NO

If YES then provide address.

Q-31. Would you like to be kept informed of the progress of this project? YES NO

Thank you for helping us with this survey. Let me give you a number to call in case you have any questions about the survey. Our number here is 404.385.0906; and my name is _____.

Post-survey Evaluation

Respondent's Attitude: HELPFUL OBLIGING IMPATIENT UNHELPFUL

Gut Instinct' Confidence Level:
KNOWLEDGEABLE TRYING BUT NOT VERY KNOWLEDGEABLE
NOT TRYING-NOT KNOWLEDGEABLE

TELEPHONE SURVEY FORM: SE-1 ESSENTIAL FACILITIES SURVEY: HOSPITALS

Facility: _____

Contact: _____ Position/Title: _____

Phone: _____

Address: _____

_____

Call Record:		
date/time:	person contacted:	comment:

Hello, my name is _____. I am calling from Georgia Tech in Atlanta, Ga. We are working on behalf of the Mid-America Earthquake Center conducting a survey of essential facilities in the New Madrid Fault Zone. Could you, or could someone there, answer a few questions for us about your building?

Q-1. What is the street address for this hospital?

_____

Q-2. Who is the best person to contact about the hospital's physical structure?

_____ position/title: _____

Q-3. What is the fax number for this hospital?

_____

Q-4a. Does the hospital stand by itself or is it connected to another building?

STAND ALONE CONNECTED

(if standing alone go on to question Q-5)

Q-4b. What is the other building used for?

_____

Q-4c. Was the other building built at the same time as the hospital?

_____

If not, do you know when it was built?

_____

Q-4d. Is this an estimate? YES NO

Q-4e. How are the two buildings connected?

_____

Q-5. How many floors does the hospital have? _____

Q-6a. What year was the hospital built? It is okay to estimate the year. _____

Q-6b. Is this an estimate? YES NO

Q-7a. How many employees are normally at the hospital?
Daytime: _____ Night: _____

Q-7b. On Call: _____

Q-8. How many patients does the hospital hold? _____

Q-9c. Does the hospital have a parking garage? YES NO DON'T KNOW

Q-9a. (If "YES")How many cars does it hold? _____

Q-10a. Is the building basically a box or rectangle? BOX RECTANGLE
(if YES go on to question Q-11) NO DON'T KNOW

Q-10b. Is the building "T" or "L" shaped? "T" "L" NEITHER
(if "T" or "L" go on to question Q-11)

Q-10c. Describe the shape of the building as if you were seeing it from above.

sketch

_____

_____

_____

Q-11. Does this hospital have an emergency power generator? YES NO DON'T KNOW

Q-12. Does this hospital have an emergency water supply? YES NO DON'T KNOW

Q-13a. Does the hospital have any meeting rooms? YES NO DON'T KNOW

Q-13b. (if 'YES') About how many people does the meeting room hold comfortably? _____

Q-14. Does the hospital have a kitchen? YES NO DON'T KNOW

Q-15a. Does the station have a radio transmitter tower? YES NO
(If NO go on to question Q-16)

Q-15b. How tall is the tower? _____

Q-15c. Is the tower on top of the station? YES NO

Q-15d. (If "NO") How far away from the station is it? _____

Q-16. Does the hospital have a helicopter landing pad? YES NO

Q-17a. What is the square footage of the building? _____

Q-17b. Is this an estimate? YES NO

Q-18. Does the building have a basement? YES NO

Q-19a. Has this building always been used as a hospital? YES NO DON'T KNOW

Q19b. (if "NO") What was it used for in the past?
Original use: _____
Other uses: _____
_____

I have just a few more questions about the building.

Q-20. Is this building a mobile home or trailer? YES NO

(If YES go on to question Q-26)

Q-21. Is the frame of the building wood, steel, concrete or brick?

WOOD STEEL CONCRETE BRICK UNKNOWN

(If WOOD go to question Q-22
STEEL go to question Q-23,
CONCRETE go to question Q-24,
BRICK go to Q-25, UNKNOWN go to Q-26)

Q-22a. Is the frame covered by masonry? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-22b. (if "YES") Is it reinforced masonry? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Go on to question Q-26.

Q-23a. Is the building a 'pre-fab' steel structure? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-23b. What are the exterior walls made out of? _____

Q-23c. What are the interior walls made out of? _____

Q-23d. Is the frame braced or is it a moment resisting frame?

BRACED MOMENT NEITHER DON'T KNOW

Go on to question Q-26.

Q-24a. Is the building built with pre-cast tilt-up walls? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

(If YES go on to question Q-26)

Q-24b. Is the building built with a pre-cast frame? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

(If YES go on to question Q-26)

Q-24c. Is it a moment resisting frame? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-24d. What are the in-fill walls made of? UNREINFORCED MASONRY
OTHER: _____

Go on to question Q-26.

Q-25a. Is the masonry reinforced? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-25b. (If "NO") What is the diaphragm made of? WOOD STEEL CONCRETE DON'T KNOW

Q-26a. Viewed from the front, is the building symmetrical or asymmetrical in structure?

SYMMETRICAL ASYMMETRICAL DON'T KNOW

Q-26b. If 'asymmetrical' describe: _____

Q-27a. Is the building elevation even across the roof?

REGULAR IRREGULAR DON'T KNOW

Q-27b. If 'irregular' describe: _____

Q-28a. Has the building been seismically retrofitted? YES PRETTY SURE DON'T THINK SO
NO DON'T KNOW

(If NO go on to END)

Q-28b. When was the retrofitting done? _____

Q-28c. Is this an estimate? YES NO

Q-28d. What was done? _____

_____

_____

END

Q-29. Does this building have any other special properties that we have not asked you about?

_____

_____

_____

Q-30. Do you have a photograph of the building that you could send to us? YES NO

If YES then provide address.

Q-31. Would you like to be kept informed of the progress of this project? YES NO

Thank you for helping us with this survey. Let me give you a number to call in case you have any questions about the survey. Our number here is 404.385.0906; and my name is _____.

Post-survey Evaluation

Respondent's Attitude: HELPFUL OBLIGING IMPATIENT UNHELPFUL

Gut Instinct' Confidence Level:
KNOWLEDGEABLE TRYING BUT NOT VERY KNOWLEDGEABLE
NOT TRYING-NOT KNOWLEDGEABLE

TELEPHONE SURVEY FORM: SE-1 ESSENTIAL FACILITIES SURVEY: SCHOOLS

Facility: _____

Contact: _____ Position/Title: _____

Phone: _____

Address: _____

_____

Call Record:		
date/time:	person contacted:	comment:

Hello, my name is _____. I am calling from Georgia Tech in Atlanta, Ga. We are working on behalf of the Mid-America Earthquake Center conducting a survey of essential facilities in the New Madrid Fault Zone. Could you, or could someone there, answer a few questions for us about your building?

Q-1. What is the street address for this school?

_____

Q-2. Who is the best person to contact about the school's physical structure?

_____ position/title: _____

Q-3. What is the fax number for this school? _____

Q-4a. Does the school stand by itself or is it connected to another building?

STAND ALONE CONNECTED

(if standing alone go on to question Q-5)

Q-4b. What is the other building used for?

_____

Q-4c. Was the other building built at the same time as the school? YES NO

If not, do you know when it was built?

_____

Q-4d. Is this an estimate? YES NO

Q-4e. How are the two buildings connected?

_____

Q-5. How many floors does the school have? _____

Q-6a. What year was the school built? It is okay to estimate the year.

_____

Q-6b. Is this an estimate? YES NO

Q-7. How many employees are normally at the school? _____

Q-8. How many students does the school hold? _____

Q-10a. Is the building basically a box or rectangle? BOX RECTANGLE
(if YES go on to question Q-11) NO DON'T KNOW

Q-10b. Is the building "T" or "L" shaped? "T" "L" NEITHER
(if "T" or "L" go on to question Q-11)

Q-10c. Describe the shape of the building as if you were seeing it from above.

sketch

_____

_____

_____

Q-11. Does this school have an emergency power generator? YES NO DON'T KNOW

Q-13a. How many gymnasiums and auditoriums does the school have?

Gymnasiums _____ Q-13b. # of seats: _____

Auditoriums _____ Q-13b. # of seats: _____

Q-13c. Does the school have an indoor track? YES NO DON'T KNOW

Q-13d. Does the school have an indoor pool? YES NO DON'T KNOW

Q-14. Does the school have a kitchen? YES NO DON'T KNOW

Q-17a. What is the square footage of the building? _____

Q-17b. Is this an estimate? YES NO

Q-18. Does the building have a basement? YES NO

Q-19a. Has this building always been used as a school? YES NO DON'T KNOW

Q19b. (if "NO") What was it used for in the past?
Original use: _____
Other uses: _____
_____

I have just a few more questions about the building.

Q-20. Is this building a mobile home or trailer? YES NO

(If YES go on to question Q-26)

Q-21. Is the frame of the building wood, steel, concrete or brick?

WOOD STEEL CONCRETE BRICK UNKNOWN

(If WOOD go to question Q-22
STEEL go to question Q-23,
CONCRETE go to question Q-24,
BRICK go to Q-25, UNKNOWN go to Q-26)

Q-22a. Is the frame covered by masonry? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-22b. (if "YES") Is it reinforced masonry? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Go on to question Q-26.

Q-23a. Is the building a 'pre-fab' steel structure? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-23b. What are the exterior walls made out of? _____

Q-23c. What are the interior walls made out of? _____

Q-23d. Is the frame braced or is it a moment resisting frame?

BRACED MOMENT NEITHER DON'T KNOW

Go on to question Q-26.

Q-24a. Is the building built with pre-cast tilt-up walls? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

(If YES go on to question Q-26)

Q-24b. Is the building built with a pre-cast frame? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

(If YES go on to question Q-26)

Q-24c. Is it a moment resisting frame? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-24d. What are the in-fill walls made of? UNREINFORCED MASONRY
OTHER: _____

Go on to question Q-26.

Q-25a. Is the masonry reinforced? YES PRETTY SURE DON'T THINK SO NO DON'T KNOW

Q-25b. (If "NO") What is the diaphragm made of? WOOD STEEL CONCRETE DON'T KNOW

Q-26a. Viewed from the front, is the building symmetrical or asymmetrical in structure?

SYMMETRICAL ASYMMETRICAL DON'T KNOW

Q-26b. If 'asymmetrical' describe: _____

Q-27a. Is the building elevation even across the roof?
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Q-28a. Has the building been seismically retrofitted? YES PRETTY SURE DON'T THINK SO
NO DON'T KNOW

(If NO go on to END)

Q-28b. When was the retrofitting done? _____

Q-28c. Is this an estimate? YES NO

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_____

_____

END

Q-29. Does this building have any other special properties that we have not asked you about?

_____

_____

_____

Q-30. Do you have a photograph of the building that you could send to us? YES NO

If YES then provide address.

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Post-survey Evaluation
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Gut Instinct' Confidence Level:
KNOWLEDGEABLE TRYING BUT NOT VERY KNOWLEDGEABLE
NOT TRYING-NOT KNOWLEDGEABLE

Appendix B

Flow Diagram for Determining Building Types