MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph. D.
Director

BULLETIN 31

THE TUPELO TORNADO

By
WILLIAM CLIFFORD MORSE, Ph. D.
STATE GEOLOGIST

UNIVERSITY, MISSISSIPPI
1936

FRONTISPIECE

A northeasterly view of the path of the tornado that swept across Tupelo, Miss., from the intersection of Main Street and the Frisco Railroad to Gum Pond, April 5, 1936. In addition to the devastated swath, from which much of the wreckage had been cleared by hundreds of relief workers, the photograph shows the line of visiting automobiles that was permitted to enter the city Sunday, April 12, 1936, for the first time. -- Courtesy of The Commercial Appeal, Memphis, Tenn., air service.

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LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey,
University, Mississippi, April 11, 1936

Dr. A. B. Butts, Chancellor
University, Mississippi

Dear Chancellor Butts:

I am transmitting herewith a short article on certain phases of the Tupelo Tornado, in the hope that it will lead to the building of better and safer cities. It is to be published, with your approval, as Bulletin 31.

Very sincerely and cordially yours,

WILLIAM CLIFFORD MORSE, Director

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THE TUPELO TORNADO

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STATE GEOLOGIST

INTRODUCTION

On Sunday April 5, 1936, about nine in the evening, a tornado dipped to Earth west of Tupelo, destroyed its western suburb, and then laid low a broad swath from the southwest toward the northeast through the residence section of that beautiful city of northeastern Mississippi (Frontispiece and Figures 1 and 2). When at noon on Friday April 10, she had laid to rest the last body, her buried dead numbered 233, her injured in hospitals in Meridian, in other Mississippi towns, in Birmingham, Alabama, and in Memphis, Tennessee, numbered other hundreds, and her property loss reached into the millions.

Despite the swiftness of the blow, the frightful loss of life, the staggering destruction of property, the people of that city have lifted their heads from grief to face the future in an unconquerable determination to rebuild a better, greater, and fairer city. Such an unquenchable spirit makes them neighbors to the rest of the world.

As great as the destruction of life was, one shudders to think how much greater it might have been had the storm struck a few minutes earlier when one congregation of Tupelo's people was at worship in the High School auditorium whose roof and walls collapsed, or had it come during school hours when hundreds of her children were gathered in the old Church Street Grammar School whose brick walls crushed to the floor the little desks over three-fourths of the area of a number of rooms.

Whenever such disasters befall any section, it is customary in insurance and legal procedure to refer to the destruction as an act of God. But is it? Rather is it not a catastrophe in which man is even more responsible than the Almighty, upon whom he is so prone to place all responsibility? To be sure, man cannot control these natural elements in their fury, but does it follow that because he cannot do so, he is justified in building structures that come tumbling down upon his head, or in providing the wind with countless thousands of spears to hurl at his unprotected body? Should he not be fair?

Figure 1.—A northeasterly view of the tornado path of April 5, 1936, from Church Street, Tupelo, Miss.--Photographed April 10, 1936.

Figure 2.—A southwesterly view of the tornado path of April 5, 1936, from the same place on Church Street, Tupelo, Miss.--Photographed April 10, 1936.

Even though it be admitted that man is equally responsible and even though the work of the wind is an essential part of the study of Geology, it is not primarily for these reasons that the subject of tornadoes here and elsewhere is now discussed. It is rather the State Geologist's sense of responsibility in striving to prevent an even greater disaster in the future that prompts him to write this short bulletin. He refers especially to the need for constructing safer school buildings.

THE NATURE OF TORNADOES

A tornado is simply a small highly intensified cyclone, one or more of which normal cyclones are always present and are passing eastwardly across the United States with the prevailing winds moving in that direction. These cyclones as rain-makers redeem the eastern half of the United States from what would otherwise be a semi-arid condition similar to the section east of the Rocky Mountains. They are marked "lows" on the daily weather maps, issued by the U. S. Weather Bureau, because the barometric (air) pressure is low. Toward this low, the barometric gradient slopes from all directions, and down this slope the winds flow toward the central low. Here there is only one direction of escape, which is upward. Because of the eastward rotation of the Earth, this upward current in the northern hemisphere always takes on an anti-clockwise swirl or spiral. In the small tornado, the barometric gradient slopes steeply toward the center, which thus intensifies the velocity of the wind and the swirl. It is the intensity of this swirl that is so destructive rather than the rate of the easterly movement of the storm as a whole; and it is this cyclonic swirl that causes objects to be thrown down in any of the compass directions, depending on which of the tornadic quadrants passes over the object. Truly the wind bloweth where it listeth, but as Salisbury wrote (p. 598) it "always listeth to blow down the steepest accessible isobaric gradient."

This swirl explains why the Tupelo Battle Monument and the gate posts were blown toward the south; the High School walls, toward the east; the Grammar School walls, toward the south and toward the east; and why the Carnaggio house wall was dented toward the west. It also explains the conflicting statements of observers as to the direction of movement of the storm.

It is the intensity of this swirl of the ascending air current that gives to the tornado cloud its characteristic funnel-shape. Whenever in its eastwardly progress the bottom of this funnel dips to the surface of the Earth, destruction ensues; whenever it lifts above the surface, objects escape. This natural progress of a tornado explains why certain

Figure 3.—Cedar trees which were blown down by tornadic winds at Bell School House, Oktibbeha County, Miss., on April 20, 1920.--Courtesy of Prof. F. E. Burt.

Figure 4.—A farm house which was destroyed by tornadic winds at Bell School House, Oktibbeha County, Miss., on April 20, 1920. --Courtesy of Prof. F. E. Burt.

structures or certain areas are destroyed whereas others escape; likewise why destruction may be as great on the leeward side of a hill as on the windward.

SELECTIVE DESTRUCTION OF NATURAL OBJECTS

The tornado that dipped near Bell School House, Oktibbeha County, Mississippi, in the spring of 1920 up-rooted, twisted off, and otherwise destroyed practically every cedar tree in its path (Figure 3), as well as a farm house (Figure 4) and a barn, whereas it scarcely broke the limbs from the giant oaks (Figure 5) extending twice as high. The tornado had no particular aversion to cedar trees. Rather these trees, because of the number of their branches and the manifold number of their leaves offered so much obstruction to the swift passage of the wind that their trunks and root systems could not withstand the wind pressure which the limbs and the leaves largely developed. The oaks stood because their trunks and their root systems were more than adequate to resist the small pressure which their few open limbs developed.

For the same reasons it was a small tornado, rather than (as previously supposed) the flood waters of a stream which rose only five or six feet on the trunks of the trees along the valley south of the University of North Carolina about 1929, that felled downstream evergreen trees standing in clumps of decidious trees of the same size. Flood waters reaching no farther than five or six feet up the base of small trees of approximately the same diameter show no selective tendencies in destruction as do the winds which embrace the whole tree. Then under the same relationship as to size and species of the trees, the same winds blew up-stream evergreens that stood 30 or 40 feet above the high water mark.

SELECTIVE DESTRUCTION OF ARTIFICIAL STRUCTURES

The tornado that passed through St. Charles, Missouri, a few miles northwest of St. Louis, on July 7, 1915, leveled Borromeo Church, except for the altar and entrance ends, tore one-fourth of the roof from the Second Street Baptist Church, and scarcely damaged another building except the corner of the priest's house, which was probably bombarded by material from the Borromeo Church. It is not conceivable that the tornado desired to wreak any special vengeance upon the churches rather than upon other structures; or upon our good friends, the Catholics more than upon our good friends, the Baptists. Rather it was these structures themselves that offered more obstruction to the wind passage than they had strength of construction to withstand.

Figure 5.—Oak trees left standing among cedar trees that were destroyed at Bell School House, Oktibbeha County, Miss., on April 20, 1920.--Courtesy of Prof. F. E. Burt.

Figure 6.—The west wall of Borromeo Church, St. Charles, Mo., which was blown across the pews by the tornado of July 7, 1915. --Photographed July 9, 1915.

The west wall of Borromeo Church was blown onto the pews and the floor, as shown in Figure 6. The entrance and the altar end remained practically intact (Figures 7 and 8). Even though the steeple extended nearly twice as high as the comb of the roof, it stood with scarcely the loss of a brick, because of the strength which its closely spaced four walls imparted to it. In a similar manner, the pulpit end remained nearly intact, because of the support which even the minor partitions gave to it. The east wall fell out; the west wall caved in; both because of no adequate braces. Had the storm struck during service when the church was filled, the photographs show how complete the destruction of life would have been.

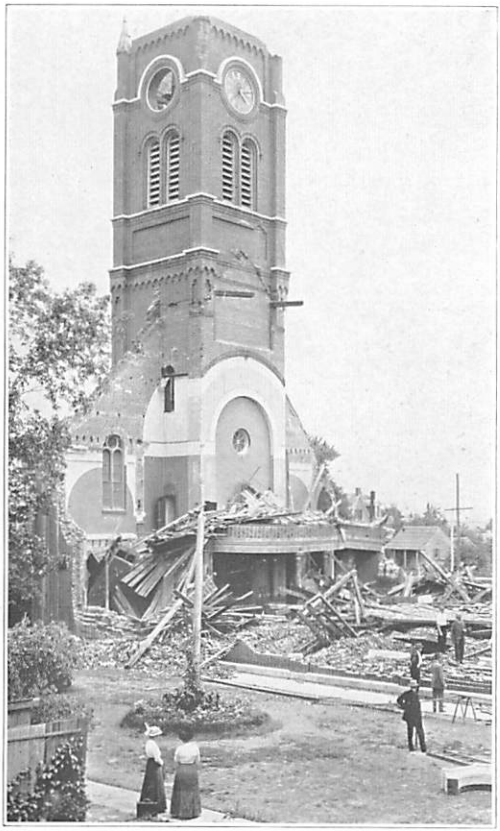

Figure 7.—The tower of Borromeo Church, St. Charles, Mo., scarcely lost a brick in the tornado of July 7, 1915.--Photographed July 9, 1915.

Figure 8.—Even frail partitions of the altar end of Borromeo Church, St. Charles, Mo., held the walls against the onslaught of the tornado of July 7, 1915. -- Photographed July 9, 1915.

Figure 9.—The north wall of the south wing of the Church Street Grammar School, Tupelo, Miss., was blown southward flat across the small desks by the tornado of April 5, 1936.--Photographed April 13, 1936.

SELECTIVE DESTRUCTION OF STRUCTURES IN TUPELO

In the swath that was cut through Tupelo as in that cut through other places, some structures were destroyed; some, partly destroyed; and others, scarcely damaged at all. That all this selective destruction was not due exclusively to the tornado, but partly to man's own imperfect building is fully set forth by the following facts.

The old Grammar School consisted of a long narrow edifice facing east on Church Street and two long narrow wings extending westward from the front. It was built of large hollow tile blocks veneered with a single brick course which was tied to the inner tile construction only at every tenth course. The mortar was largely without strength, for most of it peeled from the bricks and could readily be broken with the fingers. The long north wall of the south wing was absolutely without partition support, because a narrow hallway extended along its full length. The partitions which divided the wing into rooms were frail frame structures which extended from the hallway partition to the south outer wall. Consequently, the north wall of this wing was without the brace even of frail frame partitions. When the tornado struck, this wall offered more obstruction to the passage of the wind than it possessed construction strength to resist. Accordingly it fell southward across the hallway partition and seats, mashing all to the floor over an area of more than three-fourths of the floor space (Figure 9). Had the storm struck when the rooms of this wing were filled with pupils, the loss of life would of necessity have reached at least 75 percent of those present.

In a similar manner, the north wall of the north wing failed, falling inward, across three-fourths of the floor space of this wing (Figure 10) and much of the west wall of the front portion failed, falling inward across three-fourths of the floor space of this portion of the building (Figure 11). Therefore with the exception of the pupils in two rooms at the northeast corner and in one room at the southeast corner, at least three-fourths of all of the pupils of the whole floor would have been killed, had the storm struck during school hours.

Because of dead mortar, or mortar without strength, and especially because of inadequate braces from solid masonry cross partitions, in one and the same storm the north walls of the two wings and the west wall of the front portion fell southward and eastward respectively across the floor, thus forcing the opposite walls outward.

The more modern High School building was constructed of better brick and perhaps of slightly better mortar, yet strips of this mortar

Figure 10.—The north wall of the north wing of the Church Street Grammar School was likewise blown southward across the small desks of that wing by the tornado of April 5, 1936.--Photographed April 13, 1936.

Figure 11.—A part of the west wall of the front section of the Church Street Grammar School was blown eastward across the small desks of that section by the tornado of April 5, 1936.--Photographed April 13, 1936.

could be readily broken with the hands. The inner part of the outside walls was built two bricks in width properly tied with cross bricks, but the outer part of these outside walls was a veneer of better brick, a single brick in thickness.

As in the collapse of the Borromeo Church in St. Charles so in the partial collapse of the Tupelo High School, the main cause was inadequate cross partition braces, for the part that failed was the west wall, which was common to the auditorium and the gymnasium (Figure 12). In falling, this wall crushed the seats of the auditorium (Figure 13) to the floor and covered the free floor of the gymnasium (Figure 14). The opposite wall, also common to each of these rooms, was forced outward. The remainder of the building, the front (Figure 15) and the east wing, stood more or less completely intact. When one views the crushed seats of the auditorium and the floor of the gymnasium covered with bricks of the common wall, which stretches entirely across the two rooms, one shudders at the thought of how nearly complete annihilation would have been had these rooms been filled with pupils when the tornado struck.

The church edifices likewise wrote the record of their own failure, which was mostly due to insufficiently supported, braced, and tied roofs. Although the walls of most of them remained largely intact, the interiors of some were filled with debris from their own wreckage.

At least part of the reason why certain sections of a number of the public buildings failed whereas other sections of the same building remained almost wholly intact has been given. Now for a comparison of one structure with another.

Almost directly in front of the Church Street Grammar School is the house of Mr. Vincent Carnaggio (Figure 16) of the Dixie Cafe. Not only was the Grammar School completely wrecked, but the house on each side of the Carnaggio house was demolished (Figures 17 and 18), whereas the Carnaggio house stood almost completely intact. To be sure the spear-like lumber strips, that man had so carefully sawed from the virgin tree, shot its roof full of holes which permitted the rain to pour through; and broke its window panes; but the structure remained otherwise largely undamaged, except that one of the two supporting columns of the roof of the automobile entrance (portecochere) was thrown down, perhaps by some heavy flying object, and that a small portion of the top of the east wall near the southeast corner was forced two or three inches out of plumb by a terrific blow from some heavy timber which struck it endwise. All in the Carnaggio house

Figure 12.—The gymnasium and auditorium sections of the west wall of the west wing of the High School, Tupelo, Miss., were blown eastward across these rooms by the tornado of April 5, 1936.--Photographed April 13, 1936.

Figure 13.—The wreckage of the west wall and roof was thrown across the seats of the auditorium of the High School by the tornado of April 5, 1936.--Photographed toward the west, April 13, 1936.

Figure 14.—In a like manner the wreckage of the west wall and the roof was thrown across the floor of the gymnasium of the High School by the tornado of April 5, 1936.--Photographed toward the west, April 13, 1936.

Figure 15.—The windows and drain pipes of the south front of the High School were badly battered by flying wreckage as were the trunks and the limbs of these two trees, but this part of the building, and the east wing as well, scarcely lost a brick in the tornado of April 5, 1936.--Photographed toward the north, April 13, 1936.

Figure 16.—Aside from a badly punctured roof, which had been replaced prior to the taking of this photograph on April 13, 1936, and shattered window panes, this brick veneer house of Mr. Vincent Carnaggio on Church Street opposite the Grammar School suffered only a battered down column and a dented rear wall, solely because it was excellently constructed with high grade cement mortar.

Figure 17.—This frame house on the north side of the Carnaggio house almost completely collapsed in the tornado of April 5, 1936 --Photographed April 13, 1936.

Figure 18.—This frame house on the south side of the Carnaggio house likewise almost completely collapsed in the tornado of April 5, 1936.--Photographed April 13, 1936.

Figure 19.—Mr. J. J. Huffman stands at the spot where his sister and he escaped death on the floor deck of his house, the only part of the frame structure that was not blown away from the site at 365 North Church Street by the tornado of April 5, 1936.--Photographed April 13, 1936.

escaped injury except Mrs. Carnaggio who suffered a small forehead cut from flying window glass. The ready answer to the question as to why the Carnaggio house escaped when the house on each side was demolished is that the Carnaggio house was brick, or rather brick veneer, whereas the other two were frame structures. This is true, but it is not the complete answer.

Farther south on the same street was the frame house of Mr. J. J. Huffman, who with his sister and a deceased sister's husband was in the home when the tornado struck. The brother-in-law who was swept with the wreckage four or five houses away was so badly injured that he died some five hours later; the sister was injured, but is recovering; and Mr. Huffman, although badly cut by flying material, escaped with minor injuries. For the photograph, he posed on the deck of the floor (Figure 19), the only remaining part of his home, near the spot where his sister and he were when the house crashed. How the two escaped death is as much of a mystery to him as to others. He says the wind must have lifted the walls clear of them.

Next door was a two-story brick-veneer house, which was more pretentious than the Carnaggio brick bungalow, and which did not collapse as did the Huffman home, but which was badly wrecked (Figure 20). The roof was carried away toward the northeast; the porch roofs, wrecked; and at least three or four second floor rooms were torn down. One would expect this brick house to withstand the storm better than the Huffman frame house next door, but there is no reason why it should have been wrecked while the Carnaggio bungalow escaped largely unscathed, even though it was a two-story house and was nearer the middle of the tornado path. Perhaps the answer to this problem lies in the evidence in the State Geologist's Office, where brick and mortar from the two school buildings and the two brick houses are preserved. The brick of the two houses is the same, but the cement mortar of the Carnaggio house adheres even to the broken brick and requires a blow from a hammer to break it, whereas the mortar from the two-story house crumbles between the fingers.

Objections may be raised to the conclusions reached in this paper on the grounds that they are based on too few observations. Obviously one cannot examine every structure in the storm-swept swath more than two city blocks in width and the entire width of the city in length. It is believed that enough examples have been cited to make the conclusions valid, but more can be given. For example, the old two-story frame house on the hill that is just south of the Grammar School and

that is as high as the ceiling of the remaining part of the school building stood throughout the storm, badly damaged but not wrecked; and the two-story brick house standing on equally high ground and only one door farther from the Grammar School passed through the storm in excellent condition when compared with former surrounding structures. The roof was badly damaged, and the tops of the brick chimneys were blown off, but otherwise the brick walls were almost wholly unscathed save for a small crack extending from the window ledge of the sun porch to the ground, but this crack may have formed sometime before the storm. The first house belongs to those old frame structures that were so well constructed in an early day; and the second, to the type of brick structure that is so substantially constructed of good brick and strong cement mortar. In fact the brick in the chimney top, one brick in thickness, were sheared diagonally across and were not forced apart even on striking the ground. One piece of six such brick fragments still thoroughly cemented together is preserved with the other specimens in the State Geologist's office.

Figure 20.—This next door house, a brick veneer, was not completely blown away in the tornado of April 5, 1936, as the Huffman house was, but it is largely a wreck when compared with the Carnaggio house. Mortar so inferior as to crumble in the fingers is probably the chief reason.--Photographed April 13, 1936.

Figure 21.—The Battle of Tupelo Monument was blown down toward the south by the tornado of April 5, 1936, because its obstruction to the wind passage was too great to be overcome by the resistance of its two 14-inch and one 18-inch bases.--Photographed April 13, 1936.

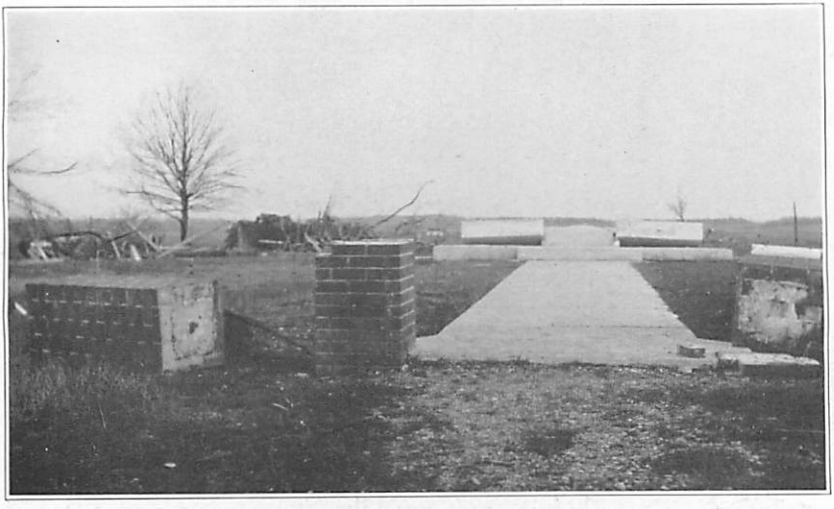

Figure 22.—Besides the Battle of Tupelo Monument, the two brick gate posts were blown down by the tornado of April 5, 1936.--Photographed April 13, 1936.

Within the small cemetery of the western suburb stood a beautiful granite Battle Monument facing the north. It consisted largely of two rectangular wings, approximately 14 inches thick, 5.5 feet wide, and 4.5 feet high, and a rectangular median part, having a basal member approximately 22 inches thick, 4.5 feet wide, and 1.5 feet high, and a main member, approximately 18 inches thick, 4.5 feet wide, and 9.0 feet high, the whole presenting a comparatively broad surface to the wind. It was toppled over toward the south, for it had only its two 14-inch bases and one 18-inch base to brace it (Figure 21). The tall, slender tubular flag-staff was bent to the ground, because at least one fairly large piece of metal roofing increased its area of

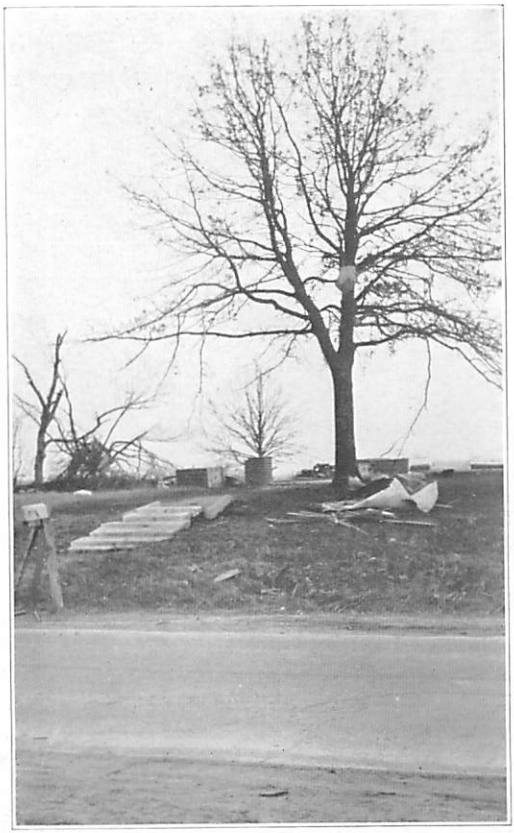

Figure 23.—Only 16 feet away from the nearest gate post stood this tree, which escaped with only slight damage to three or four limbs, because it offered so little obstruction to the passage of the tornadic winds of April 5, 1936.--Photographed April 13, 1936.

obstruction without increasing its power of resistance. Stranger still is the fact that two square solid brick gate posts were broken off (Figure 22), even though the nearer post stood only 16 feet from a tree which had only three limbs or twigs broken and which had a metal tub lodged in its branches (Figure 23). The nearby cedars were uprooted, broken, and twisted off while the larger open decidious trees were left standing largely undamaged (Figures 21, 22, and 23).

A large field on the windward side of the adjoining hill was strewn with timbers and smaller pieces of linear wreckage, all pointing toward the southeast as though every soldier in an army had thrown spears in the same direction (Figure 24). These are the missiles that man furnishes the elements to hurl against his frail body -- as if the tumbling walls were not deadly enough. Scarcely a man rushing from his crumbling home into the open could have escaped injury or death from these darts.

The same type of material was scattered less thickly over the valley bottom south of the highway farther to the east of the suburb, but such material was perfectly clear from the same valley bottom on the north side, because the flood waters carried the material down against the upstream side of the highway embankment. No further evidence of the effectiveness of these deadly missiles need be given.

Figure 24.—Fields were covered with spear-like strips which lay as if they had all been thrown in one direction by an advancing army. The Tupelo tornado of April 5, 1936.--Photographed April 13, 1936.

SUGGESTIONS FOR REBUILDING

In the past, the geologist, the architect, the engineer, the owner' the builder, and the workmen have been more or less responsible for the deadly effects of these tornadic storms. Although no one is so foolish as to believe that he can control or bridle these forces of nature, still he can by proper construction of houses and other structures reduce these deadly hazards to 20 or 25 percent of their present state, even in a highly populated area -- this conclusion notwithstanding quotations from Finley (1884) in Ward's, The Climates of the United States, page 356 (1925) to the contrary. And although the law of chance reveals that the probability of an individual's experiencing a tornado is annually only one in 625,000, the hazard of the deadly effects must still be reduced.

In the face of the evidence accumulated in the St. Charles, the Tupelo, and other tornadic storm areas, it would seem scarcely short of criminal negligence to construct large churches, auditoriums, and school assembly rooms, that of necessity must be free from partitions, without providing them with adequate buttresses, without using the best of cement mortar, and without properly re-enforcing the concrete, brick, and stone construction, and without using adequate structural steel re-enforcements.[1]

Likewise one is inviting disaster who builds a house of any but the best materials, preferably of brick, stone, and concrete, all of which can be properly reenforced with steel ties. One-story bungalows can be made safe more cheaply than two-story houses. The one story house built of rough stone such as may be obtained in Tishomingo County (See Bulletin 26) and concrete of the Ernest Flagg system is beautiful, permanent, and reasonable and may be reenforced with steel. No doubt it would be better to use hollow tile for the inner part of the walls and reenforced concrete in place of the rafters and lath of the roof, which could then be covered with some usual roofing material, of which tile is perhaps preferable. It is also perfectly possible to build a small heavily reenforced room such as a wardrobe or a clothes closet which may be used as such at all times and yet be available for refuge in time of storm. Such a room could have an outside window, properly

[1]But even Reinach in Apollo, Chapter XII, Romanesque and Gothic Architecture, after calling attention to the "inherent fragility" of extreme Gothic structures (p. 117) stated as early as 1904 that "With the help of metal, and of cement reinforced by metal bars, the moderns might equal the most daring feats of the Gothic architects; it would even be easy for them to surpass them, without endangering the solidity of the structure, as did the audacities of Gothic art" (p. 118).

shuttered, outside air conduits leading up through the floor or through the outside wall, equipped with electric, battery, and hand-powered ventilating fans, and an inside metal emergency fire door. Sections of the room could easily be made into a fire proof vault. The whole could readily be made fire proof even against asphixiation and crush proof even against the falling of the largest trees and the heaviest walls. The plan is indeed feasible.

IN CONCLUSION

Here as elsewhere, therefore, the choice seems to lie largely between the practicing of the inertia of a body at rest or the practicing of inertia of a body in motion; the building at present prevailingly low costs or the building at future slightly higher costs; the passing through a tornado with scarcely anything left or the passing through a storm with almost everything saved; the losing of friends and loved ones or the saving of friends and loved ones.