

02 Jun 1988, 10:30 am - 3:00 pm

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Recommended Citation

Van Besien, Alphonse C. and Aughenbaugh, Nolan B., "Johnston City School, Mine Subsidence or Shallow Foundation Problem?" (1988). *International Conference on Case Histories in Geotechnical Engineering*. 20.

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Johnston City School, Mine Subsidence or Shallow Foundation Problem?

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SYNOPSIS: Johnston City, a small community in southern Illinois, lies above the Herrin (Illinois No. 6) coal seam. The community has experienced sporadic episodes of surface subsidence due to the collapse of underground mines since the 1930's. Although the mining company left a large block of coal beneath the town's elementary school to prevent subsidence damage to the structure, large cracks appeared in the school building in December, 1971. After the building was razed, construction of a new school was initiated in 1974. Approximately six months after the start of construction, new evidence of structural distress was observed in the still-uncompleted structure. Construction was suspended indefinitely while site investigations were conducted. These investigations, along with recent air photo studies, indicate that renewed mine collapse and the resulting downward displacement of the surface, were the cause of this second incident of structural distress.

INTRODUCTION

Johnson City is a community of approximately 4000 population, located 85 miles (140 km) southeast of the St. Louis metropolitan area (Figure 1). Situated near the northern boundary of Williamson County, Johnson City is in the center of what was once widely known as the "Quality Circle", a portion of Illinois famous for the thickness and high quality of its coal seams. Mining of the Herrin (Illinois No. 6) coal seam, which here is eight feet (2.4 metres) thick, provided the economic life-blood of the community during the early years of this century. The Lake Creek Mine, which underlies most of the town, was closed in 1929, and surface subsidence, caused by collapse of portions of the mine workings, was observed almost immediately and at irregular intervals ever since. In 1971, the town's elementary school was damaged by what was believed to be mine subsidence, and was subsequently razed. In 1974, construction of a replacement school building was initiated on the same site. New evidence of structural distress was observed even before the replacement building was completed, and construction was suspended indefinitely. Physical evidence at the site indicates that the second episode of damage was caused by renewed collapse of the mines below Johnston City.

GEOLOGY

Stratigraphy

Johnston City is situated in the Till Plains Section of the Central Lowlands Physiographic Province. The Pleistocene deposits of this area are the Equality Formation of Wisconsin age and the Glasford Formation of Illinoian age (William and Frye, 1970). The Equality Formation is composed of lacustrine deposits of calcareous, silty, and sometimes sandy, clay representing the Periglacial Muddy Lake of Wisconsin age. The Equality clays are usually brown or yellow-brown in color. The Glasford Formation is made up of ground moraine tills of Illinoian age. In the Johnston City area, these Pleistocene materials have a combined thickness of from 50 to 100 feet (15 to 30 metres).

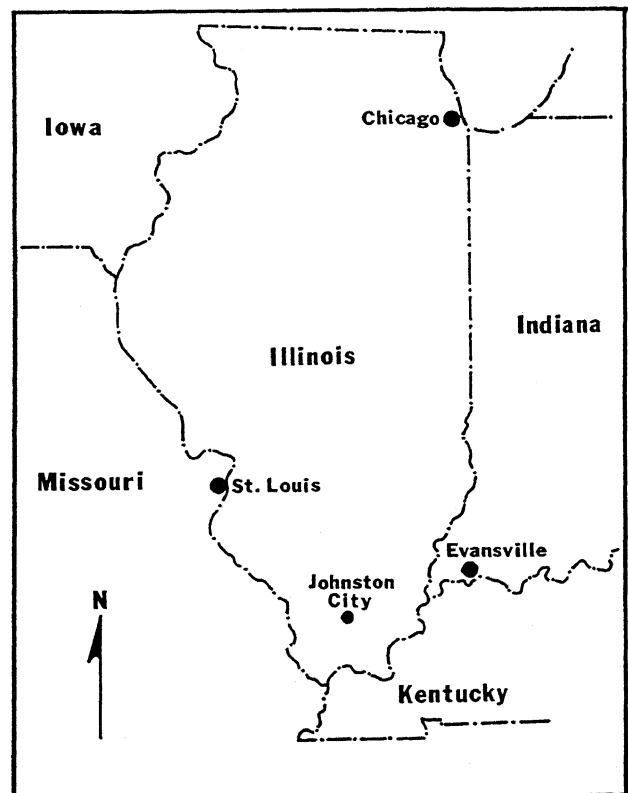


Figure 1. Location Map.

Being located near the southern boundary of the Illinois Coal Basin, Johnston City is underlain by some of the oldest formations of the Pennsylvanian System in Illinois. Most important for this study is the Carbondale Formation of the Kewanee Group. This formation includes the Herrin coal seam and extends upward to the Danville (Illinois No. 7) coal seam. The Herrin seam is usually underlain by the Energy Shale which consists primarily of a medium-gray, poorly laminated, silty shale (Damberger et al, 1980).

The Carbondale Formation is the uppermost of the Kewanee Group, and is in turn overlain by the Modesto Formation of the McLeansboro Group.

Structural Geology

The most important structural feature in the vicinity of the site is the Cottage Grove Fault System (Figure 2) which interrupts the slight regional dip to the north, trends WNW-ESE and has been characterized as a right-lateral strike-slip fault with a displacement of less than one mile (Nelson and Krausse, 1981). Numerous minor faults are associated with the system; most are normal, but reverse and oblique-slip faults have been described. Vertical displacements of up to 200 feet (60 metres) are associated with these minor faults. Subsidiary anticlines with limbs dipping up to 15 degrees have been reported in association with the Cottage Grove Fault



Figure 2. Structural features of southern Illinois.

System. In the eastern part of Williamson County, approximately 15 miles (25 kilometres) southeast of Johnston City, peridotite dikes have been reported, intruded along minor faults (Clegg, 1955). Both faults and intrusions are dated only as post-Pennsylvanian in age.

MINING HISTORY

Coal was mined in Williamson County as early as 1850, with the first shipping mine being opened in 1872 by the Carbondale Coal and Coke Company (Peltier, 1912). Mechanical mining was introduced into the area as early as 1891, although successful mechanization was delayed until 1920, when it was utilized by the Egyptian Coal and Mining Company. Room-and-Pillar mining methods were used throughout this area, with rooms 20 feet (6 m.) wide and pillars 14 feet (4.3 m.) wide. Rooms were generally 200 to 250 feet (60 to 75 m.) in length, with cross-cuts being driven at intervals of 60 feet (18 m.). The mining method produced frequent incidents of surface subsidence (Young, 1916).

The Lake Creek Coal Mine, which underlies Johnston City,

was active at the turn of the century and continued in operation until 1929. Mine layout was typical of the area with the room and pillar dimensions previously cited. Company personnel left an irregular block of coal, approximately 160 feet (48 m.) square, to provide, what was believed would be permanent protection for the elementary school against mine subsidence. In 1927, the mine encountered a Grove Fault system, which trended NNW-SSE and had a vertical displacement of approximately 60 feet (18 m.). Like most mines in the area, the Lake Creek Coal Mine experienced some problems with groundwater. Drilling performed in conjunction with these studies in the 1970's indicated that the mine was flooded.

SUBSIDENCE HISTORY

Pre-1971 Subsidence

Sporadic incidents of mine subsidence have been reported in Johnston City ever since the Lake Creek Coal Mine was abandoned. In the 1930's, the town's high school was damaged by subsidence, as were the football field and the community's baseball park. In the 1940's, two residential blocks northeast of the elementary school experienced subsidence damage. Another baseball park developed a dish-shaped subsidence depression, three feet (1 m.) deep, in 1964. In June 1965, several more homes suffered severe cracking of basement walls and foundations; cracks were also visible in the ground surface. Subsidence eventually affected so much of the town that one resident indicated, with some exaggeration, that there wasn't a house in the town where a pencil could be laid on a table without having it roll off.

1971 Subsidence

The initial subsidence damage to Johnston City's Washington Elementary School was first observed during the Christmas school holidays. Janitors working during this break discovered cracks in the walls and ceilings of eight school rooms (Figure 3). Door frames were misaligned (Figure 4) and large fractures were visible on outside foundations, sidewalks, and school playgrounds (Figure 5). Damage was so extensive that the building was declared unsafe and was demolished shortly thereafter.



Figure 3. Cracks in classroom walls and ceilings.

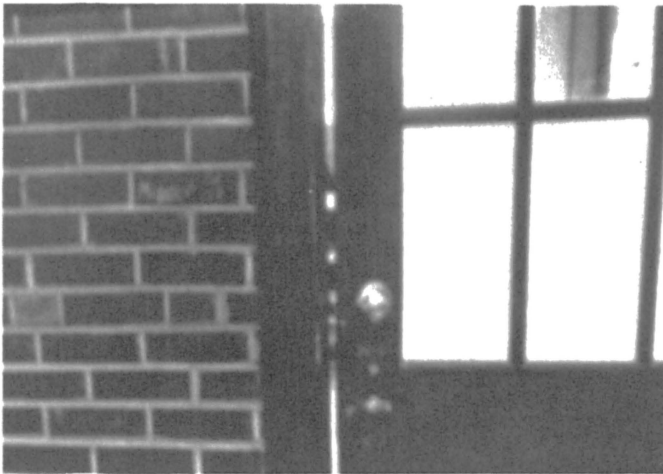


Figure 4. Misaligned door frames.

1974 Subsidence

In the belief that the mine subsidence was completed, construction of a replacement elementary school was initiated on the same site, in the summer of 1974. In October of that year, the contractor reported damage to the building under construction. The damage was in the form of dislocated and misaligned structural members. Construction was suspended indefinitely.



Figure 5. Crack in playground.

A damage survey of the area indicated that a number of residences were damaged, and that several water-main breaks occurred simultaneously with the damage to the new school building. Eight breaks were reported in the water-mains in the six blocks to the east and southeast of the school, with five occurring in the southeast. Thirty-three homes were reported to have been damaged during the suspected subsidence incident; again, most of the damage incidents were reported in the area to the southeast of the school.

Surveys accomplished during October and November of 1974 established that the center of the subsidence zone was south of the school, although the exact magnitude of the settlement could not be determined. Displacements within the school amounted to approximately 4 inches (10 centimetres). Extended observation of settlement monuments indicated that the rate of subsidence was slowing, and that, by the end of November, downward

displacement had practically ceased.

Ten borings were drilled in the vicinity of the school during these investigations. Two of the borings encountered coal, while eight borings encountered collapsed, or partially collapsed, mine workings. Where the mine was partially collapsed, openings ranging in height from 6 inches to 2.2 feet (0.2 to 0.7 m.) were encountered. Boring B-2 (Figure 6) followed a vertical fracture from near the surface to a depth in excess of 190 feet (58 metres).

Recently, air photos taken of the site in May, 1960, and December, 1974, were examined for evidence of subsidence. No evidence of subsidence was observed in the 1960 air photos (Figure 7). Digital image processing applied to the 1974 air photos revealed a lineament trending NE-SW and corresponding generally with the reported water-main breaks (Figures 6 and 8). The light-colored lineament is interpreted as a narrow zone of soil which has dried, and become lighter in color, due to the presence of an underlying fracture in the bedrock. The fracture is believed to be a tension fracture associated with the mine subsidence. Once the lineament was observed in the enhanced image, it could be observed in the original 1974 photo, although only very faintly.

Studies of mine subsidence in the United States indicate that the angle of draw, the angle between the vertical and a line drawn from the edge of the collapsing mine opening to the outer limit of surface displacement caused by subsidence, ranges from 20 to 35 degrees. With the Lake Creek Coal Mine lying at a depth of 240 to 280 feet (73 to 85 m.) below the surface, the coal Pillar was not large enough to prevent subsidence damage to the school, if the area of mine collapse was near the school.

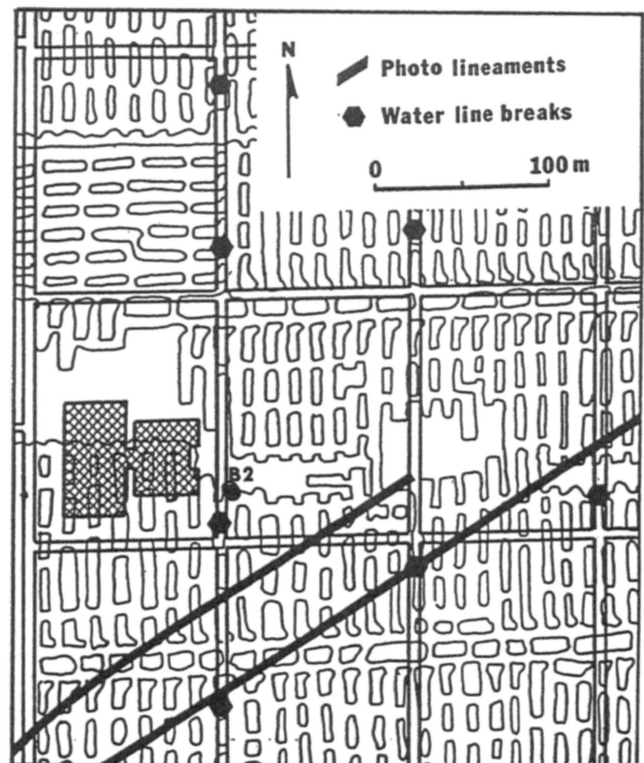


Figure 6 Mine layout and indications of subsidence.



Figure 8. Air photo of Johnston City in 1974.

CONCLUSIONS

Although other explanations have reportedly been offered for the damage to the Johnston City elementary school buildings, there can be little doubt that both damage incidents were caused by mine subsidence. The occurrence of only-partially-collapsed mine openings in the immediate vicinity of the school, coupled with water-main ruptures, damage to private residences, surveyed displacements of the ground surface and the fractures observed in the ground surface at the time of the original damage to the old school building, are strongly indicative of subsidence damage. The lineaments observed in the digitally enhanced air photos, taken after the damage of the replacement school building, and generally coinciding with water-main ruptures, are consistent with subsidence-related ground displacements. The presence of only-partially-collapsed mine openings near the school after the second subsidence incident, indicates that additional subsidence, although probably of lesser magnitude, was possible after 1974.

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