108650

REPORT BY THE

Comptroller General

OF THE UNITED STATES

RELEASED

9153

RESTRICTED — Not to be released outside the General Accounting Office except on the basis of specific approval by the Office of Congressional Relations.

Alternatives To Protect Property Owners From Damages Caused By Mine Subsidence

Underground coal mining can cause subsidence--the displacement or sinking of the ground surface--which in turn can damage surface structures in urban areas and result in serious financial consequences for property owners.

GAO identifies five alternatives to protect property owners from severe financial hardship by preventing or correcting subsidence damage, and makes several recommendations to the Secretary of the Interior to help reduce future subsidence damage.

This report is in response to a request from Congressmen Paul Simon and Morris K. Udall.

503615

report restricted

CED-79-25

FEBRUARY 14, 1979

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-190462

The Honorable Morris K. Udall and
The Honorable Paul Simon
House of Representatives

As you requested, this is our report on Federal, State, and local efforts to control mine subsidence. In the report we discuss several methods to minimize or avoid subsidence damage. We also identify alternatives to protect property owners from damage caused by coal mine subsidence.

As agreed with Congressman Simon's office we have not obtained written agency comments. The matters covered in this report, however, were discussed with responsible Federal and State officials; their comments are incorporated where appropriate.

Unless you publicly announce its contents earlier, we plan no future distribution of the report until 7 days from the date of the report. At that time, we will send copies to interested parties and make copies available to others upon request.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO CONGRESSMEN
Paul SIMON AND
MORRIS K. UDALL

ALTERNATIVES TO PROTECT PROPERTY OWNERS FROM DAMAGES CAUSED BY MINE SUBSIDENCE

D I G E S T

Property owners and local governments face possible severe structural damage and expensive repairs to homes, buildings, roads, and utility lines when abandoned underground mines collapse. According to a Department of Housing and Urban Development contractor, the annual cost of surface subsidence damage--sinking of the ground surface--is estimated at $30 million. GAO identified the following possible alternatives each with pros and cons which, if used, may protect property owners from severe financial hardship:

--Insurance programs, such as those in Pennsylvania and Illinois, to provide direct financial relief to property owners.

--Federal aid by classifying subsidence a disaster and providing emergency relief or creating a Federal or other mine subsidence program.

--Land use controls such as zoning and subdivision regulations.

--Building standards whereby government can control building design and construction.

--Filling mine voids to minimize or reduce future subsidence over abandoned mines. (See p. 30.)

GAO found that there is no Federal, State, or local mechanism to obtain comprehensive data on the nature, frequency, and severity of subsidence occurrences. This data would

CED-79-25

be helpful to better understand subsidence and develop remedies to solve the problem. (See p. 6.)

The Secretary of the Interior should:

--Develop information on total extraction mining methods and applications with controlled subsidence.

--Promote using such methods where possible when discharging mining oversight responsibilities with States and coal mine operators.

--Establish a centralized mechanism for collecting, analyzing, and coordinating data essential for assessing subsidence's nationwide impact.

--Develop remedies to solve the problem considering alternatives GAO identified. (See p. 29.)

EXTENT OF SURFACE SUBSIDENCE FROM ACTIVE AND ABANDONED MINES

Subsidence data is not collected systematically by any Federal, State, or local agency. GAO, however, identified two nationwide estimates--one by the Bureau of Mines and the other by a Department of Housing and Urban Development Office of Policy Development and Research contractor--which included estimates of subsidence surface effects.

The Bureau estimated that over 8 million acres have been undermined in the United States in extracting coal, metals, and nonmetals. Subsidence has affected over 2 million acres, or 25 percent, of the undermined area. Over 99 percent of the subsidence is attributed to underground coal mining while other mining activities account for less than 1 percent. Substantial potential exists for some of the remaining 6 million acres to subside. (See pp. 3 and 4.)

The Bureau also estimated that, on the basis of anticipated underground production of coal, metals, and nonmetals and no significant changes in past practices, mining methods, or scientific subsidence controls, an additional 2.5 million acres will be undermined in the United States by the year 2000. According to the Bureau, about 2 million of the 8.5 million undermined acres--6 million from past mining and 2.5 million from future mining--will subside unless adequate preventive measures are taken. (See p. 4.)

Underground mine subsidence damage has been most widespread in Pennsylvania and Illinois. For example, the Pennsylvania mine subsidence insurance program paid damage claims totaling over $2 million between 1961 and 1978 and repair costs on recent claims averaged about $5,000 per home. However, State officials told GAO that only about 3 percent of those living in subsidence prone areas are insured and many subsidence damage incidents have not been reported for fear of loss in property value. (See p. 12.) Also, a partially constructed school in Illinois had to be abandoned after over $1 million had been expended. (See p. 8.)

ACTIVE MINES LEAD TO SUBSIDENCE

Federal, State, and local officials generally agree that active mines will lead to future subsidence, but not necessarily cause subsidence damage. Pennsylvania permits mining near or under populated areas and active mining has caused subsidence damage in such areas despite State regulatory measures to prevent it. Coal mine operators in Pennsylvania have paid 264 property owners over $1.1 million since 1966 for such damage. (See pp. 5, 12, and 25.)

In eight of the nine States GAO visited, mining activities were conducted mostly in rural or unpopulated areas and accordingly, should not cause subsidence damage to surface structures. Homes built over abandoned

underground coal mines, however, could incur future subsidence damage. (See p. 5.)

METHODS FOR CONTROLLING SUBSIDENCE

Mine subsidence can be controlled or avoided by:

--Not mining the resource.

--Mining the resource using techniques causing subsidence in a planned or calculated manner.

--Mining the resource and leaving an adequate amount of coal for surface support. (See p. 3.)

Regulatory measures and mining methods have been applied in attempts to control subsidence. Federal efforts include projects to backfill abandoned mine voids. Also, the Surface Mining Control and Reclamation Act of 1977 provides for maximizing mine stability, filling abandoned mine voids, and prohibiting or suspending any coal mining which will create an imminent danger to public health and safety. (See pp. 23 and 24.)

Government and industry officials believe that, when possible, calculated mining techniques using total extraction mining methods with mine roof collapse followed by surface development are the optimum subsidence damage prevention procedures. Such methods, however, are not always feasible and practical or environmentally acceptable. (See pp. 26 and 27.)

GAO did not obtain written agency comments. The matters covered in this report, however, were discussed with responsible Federal and State officials; their comments are incorporated where appropriate.

Contents

ABBREVIATIONS

BOM	Bureau of Mines
GAO	General Accounting Office
HUD	Department of Housing and Urban Development
OSMRE	Office of Surface Mining Reclamation and Enforcement
USGS	United States Geological Survey

CHAPTER 1

INTRODUCTION

Subsidence is the vertical displacement or sinking of the ground surface caused by either natural phenomena or man's activities. Extracting subsurface materials--fluids and solids--accounts for most man-induced subsidence in this country.

Most mining-related subsidence damage results from the collapse of voids created by underground coal mining. Subsidence from coal mining may occur within a few weeks or be delayed for years, depending on the mineral layer's depth below the surface, the overlying rock strata's characteristics, the mining methods that were employed, and time deterioration of the mine structure.

On February 21, 1978, Congressmen Paul Simon and Morris K. Udall asked us to study surface impacts caused by underground mining. Our study was directed toward

--determining the extent of surface subsidence damage resulting from both coal and noncoal mining and how much damage occurs above abandoned mines compared to active mines,

--determining whether modern active mines are leading to subsidence,

--identifying methods for controlling subsidence,

--identifying means for protecting property owners (including governmental units) from subsidence-caused damage,

--determining the annual cost for repairing subsidence-related damage in the United States, and

--identifying alternatives for paying repair costs for subsidence damage to homes and public buildings.

SCOPE OF REVIEW

Our work was done at Federal and State offices in Pennsylvania, Illinois, Missouri, Kentucky, West Virginia, Ohio, and New Jersey. We also reviewed and discussed subsidence research and demonstration projects with Federal

officials in Colorado and Wyoming. We inspected subsidence-damaged areas in the above States. Our review also included work at the Departments of the Interior, Commerce, and Housing and Urban Development in Washington, D.C.

In selecting States we considered those with substantial underground mining activities, subsidence problems, or special projects relative to subsidence. Since available studies attributed subsidence problems primarily to underground coal mines, we concentrated on coal mining States.

In carrying out our work, we

--reviewed Federal and State legislation pertaining to mine subsidence;

--inspected subsidence-damaged homes, schools, buildings, roads, or utilities in the States visited;

--interviewed Federal, State, and local officials; coal and insurance industry officials; and private citizens; and

--examined pertinent Federal and State documents, reports, records, and files.

CHAPTER 2

MINE SUBSIDENCE--EXTENT, EFFECTS, AND CONTROLS

Mine subsidence is a localized problem with serious financial consequences to property owners--especially homeowners. According to a recent Department of Housing and Urban Development (HUD) Office of Policy Development and Research contract report, mine subsidence primarily from abandoned underground coal mines results in estimated annual damage costs of $30 million. The Bureau of Mines (BOM) estimated that about 2 million acres of undermined land has subsided and an additional 2 million acres will subside by the year 2000. Although mine subsidence damage has occurred in many States, it has been most widespread in Pennsylvania and Illinois. Subsidence damages buildings and homes, pavements, streets, and subsurface pipelines and facilities. Mine subsidence can be controlled or avoided by

--not mining the resource,

--mining the resource using techniques causing subsidence in a planned or calculated manner, or

--mining the resource and leaving an adequate amount of coal for surface support.

Regulatory measures and mining methods have been applied in attempts to control subsidence.

EXTENT OF SUBSIDENCE DUE TO ACTIVE AND ABANDONED MINES

According to Federal, State, and local officials visited, subsidence data is not collected systematically by any Federal, State, or local agency. Consequently, comprehensive data is not maintained on the amount of subsidence and related damage occurring nationwide. However, there are two studies with nationwide estimates--one done by BOM and the other one done by a HUD contractor.

BOM estimated that over 8 million acres have been undermined in the United States in extracting coal, metals, and nonmetals. Subsidence has affected over 2 million acres or 25 percent of the undermined area. Underground

mining of bituminous 1/ coal accounts for 1.9 million acres, or 95 percent of the subsidence; anthracite 2/ mining for 90,000 acres; and metal and nonmetallic mineral mining for about 17,000 acres. Thus, over 99 percent of the subsidence is attributed to underground coal mining while noncoal mining activities account for less than 1 percent. Substantially more bituminous coal is produced annually than anthracite coal. Production in 1977 totaled about 688 million tons for bituminous and 6 million tons for anthracite.

BOM believes there is substantial potential for some of the remaining 6 million undermined acres to subside. BOM estimated that an additional 2.5 million acres will be undermined in the United States by the year 2000 based on anticipated underground production of over 15 billion tons of coal, metals, and nonmetallic ores, provided there are no significant changes in past practices, mining methods, or scientific subsidence controls. According to BOM estimates, about 2 million of these 8.5 million undermined acres--6 million from past mining and 2.5 million from future mining--will subside unless adequate preventive measures are taken.

BOM also identified 262 specific urban areas in 29 States where either subsidence has occurred or potential for future occurrences exist due to underground mining. (See app. I.) Not all subsidence in urban areas is severe. Some damage is minor and often cannot be distinguished from that due to inferior construction. In many instances, buildings situated well within the limits of an extensively subsided area have settled uniformly and without any apparent structural damage.

A 1977 HUD contractor-prepared report identified 220 counties in 42 States with underground mining and showed that subsidence has occurred in 30 of those States. (See app. II.) According to the report there appeared to be

--widespread subsidence in two States--Pennsylvania and Illinois;

1/Bituminous coal is soft coal used most commonly for industrial purposes, power generation, and space heating.

2/Anthracite coal is hard coal used primarily for space heating.

--serious subsidence in localized areas of West Virginia, Montana, Wyoming, Colorado, and (in the past) Oklahoma, Arkansas, and Missouri; and

--isolated incidents in Indiana, Washington, New Jersey, Kansas, Maryland, Nevada, and Ohio.

We found that most known subsidence damage occurred in Pennsylvania and Illinois. According to the HUD report, however, subsidence damage resulting from underground mines may increase in other States as mine supports deteriorate and surface development spreads over undermined areas. Federal and State officials told us that most subsidence impact has been from abandoned underground coal mines and the most serious problems occur with the spread of urbanization into undermined areas.

Federal, State, and local officials generally agreed that active mines will lead to future subsidence, but will not necessarily cause subsidence damage after mining activities have ceased or mines have been abandoned. Officials in eight of the nine States visited told us that mining activities were conducted mostly in rural or unpopulated areas and, accordingly, should not cause subsidence damage to surface structures. Subsidence damage, however, could occur as in the past if surface development extends over undermined areas.

Pennsylvania permits bituminous coal mining near or under populated areas and active mining has resulted in subsidence damage in such areas. Pennsylvania has developed information on the amount of coal that should remain unmined to support surface structures. Although the State is required to enforce such support measures, active mining activities have resulted in subsidence damage as evidenced by 264 claims totaling over $1.1 million paid by bituminous coal mine operators since 1966. The State requires bituminous coal mine operators to reimburse owners of protected homes for subsidence damage caused by active mines.

Owners of structures built after 1966 in the bituminous area are not protected but have two options to protect against subsidence damage due to active mining. They may (1) purchase unmined coal to provide surface support or (2) purchase State subsidence insurance.

Underground coal mining is also conducted on Federal lands under lease arrangements with mining companies. The U.S. Geological Survey (USGS) has been responsible for

monitoring Federal coal leases on Federal land. USGS officials told us that subsidence has not damaged homes and buildings on Federal land because the lands leased for such mining activities are located mostly in rural or unpopulated areas. Due to the Surface Mining Control and Reclamation Act of 1977 the function of monitoring subsidence under Federal coal leases has been transferred to the Office of Surface Mining Reclamation and Enforcement (OSMRE).

MINE SUBSIDENCE EFFECTS

We visited many locations in States where subsidence occurred and observed subsidence damage to structures and residences. Some residents were concerned about repair costs and future subsidence problems. Public officials expressed similar concern about public property such as school buildings and roads.

Mine subsidence can pose serious hazards to the socioeconomic, psychological, and physical well-being of individuals and communities. Ground subsidence may have some effect on the natural environment by destroying wildlife and natural habitats, altering plant and animal life patterns, and altering surface and subsurface patterns.

The BOM and HUD contractor studies contained information on damage costs. The estimates were qualified due to various assumptions and computation procedures used. According to the HUD report:

> "* * * there are no valid data relating to the nature, frequency, magnitude or severity of subsidence occurrences in the country: nor is there any existing mechanism by which these data could be collected, compiled and analyzed. Yet, these data are essential for assessing the impact of subsidence nationwide. These data are also essential for decisionmaking with respect to housing and community development activities in subsidence-prone terranes."

Socioeconomic effects

BOM estimated that underground coal mining will cause surface damage costs well in excess of $1 billion from 1973 to the year 2000. A HUD contract report estimated that underground mining primarily from coal mines causes about $30 million annual subsidence damage to structures. Our

analysis of their estimate indicated that the $30 million could be segregated as follows:

	Amount	Percent
	(millions)	
Residential buildings	$ 5.7	19
School buildings	10.8	36
Commercial and industrial buildings	10.8	36
Roads, utilities, and services	2.7	9
Total	$30.0	100

The above estimate includes only structural damage and not other economic impacts including:

--Loss of farmland value in terms of livestock losses in collapsed mines or sinkholes, cropland loss, alteration of drainage patterns, or loss of water supplies.

--Dislocation losses suffered during repairs, such as business losses and extra costs incurred by non-business institutions and families during repairs.

--Land value depreciation in areas known to be subject to subsidence, such as loss of value for land on which development is prohibited by public laws based on the geographical hazard.

--Value of resources abandoned to support surface development. The resources' value is forfeited by the mining company or is borne as costs by the surface property owner who must buy the unmined resources to support his property and avoid subsidence. The resources' value should be considered in determining total subsidence costs.

--Adverse effects on economic growth if new industries or other economic activities are prevented or deterred from locating in a subsidence-prone area or community by a real or perceived hazard.

The general public bears the financial burden for subsidence damage--directly by property owners or indirectly through taxes or increased service costs.

Physical effects

According to a HUD contract report, the typical physical effects in urban areas include

--cracked foundations, walls, and ceilings;

--weakened floors and foundations--sometimes sufficiently to cause collapse;

--cracked and collapsed streets;

--ruptured water, sewer, and gas lines; and

--altered water drainage patterns.

The following examples depict the above effects observed in selected States.

Illinois

Surface subsidence above abandoned underground coal mines is a serious problem particularly affecting the central and southern areas of Illinois. The presence of a greater number of limestone strata, which are unlike the "self-healing" shale strata of Appalachia, make subsidence damage more prominent. Since 1970, at least 60 homes, 4 schools, a church, commercial buildings, an airport, a dam, and a cemetery incurred millions of dollars in subsidence damage. According to BOM, subsidence potential will increase as coal becomes a primary energy source. Only 9 billion tons, or 5 percent, of Illinois coal resources of 180 billion tons have been mined.

Figures 1 and 2 on page 9 show a partially constructed school at Johnston City which had to be abandoned after over $1 million had been expended. The school was constructed on the site of a 32-year old school which suffered subsidence damage in 1971 and was demolished. This site was approved by a private soil testing firm but the new school suffered subsidence damage during construction and was abandoned. A new school is under construction on another site not undermined.

Figure 3 on page 10 shows a 30-year old Belleville elementary school abandoned after suffering subsidence damage in 1970.

Figures 4 and 5 on page 11 show 2 of about 20 subsidence-damaged homes in a Maryville 60-home development.

PARTIALLY CONSTRUCTED AND ABANDONED $1.4 MILLION WASHINGTON SCHOOL
JOHNSTON CITY, ILLINOIS

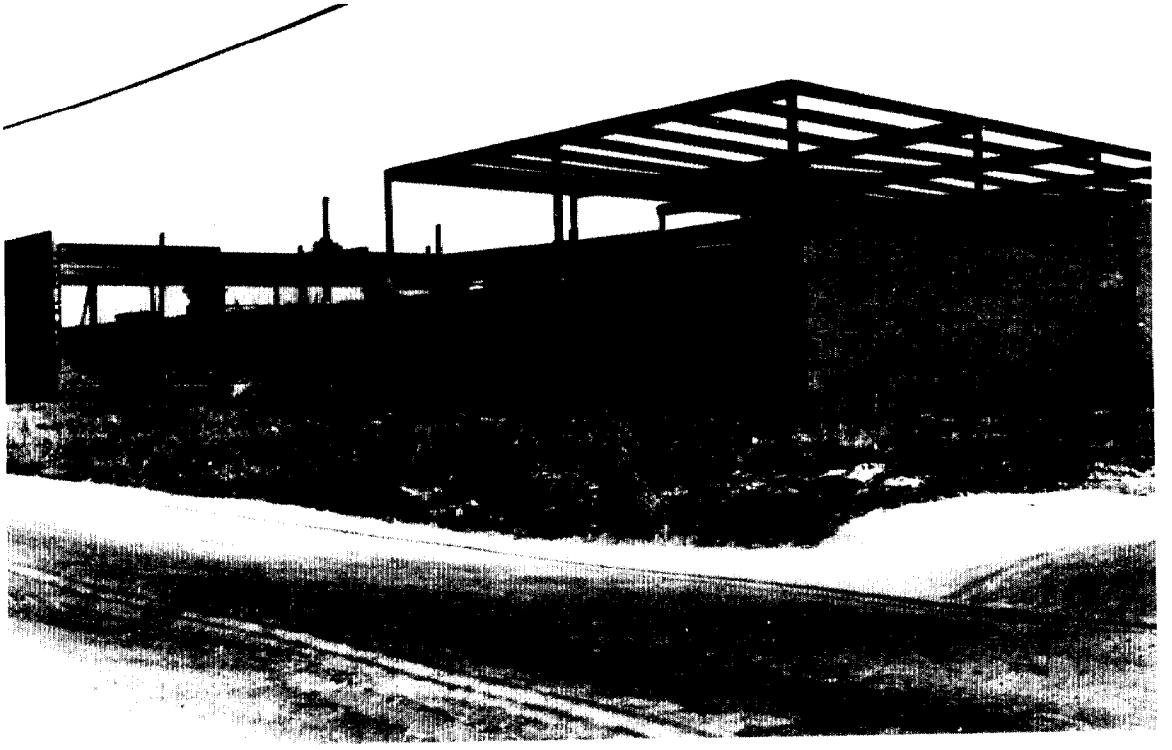


FIG. 1

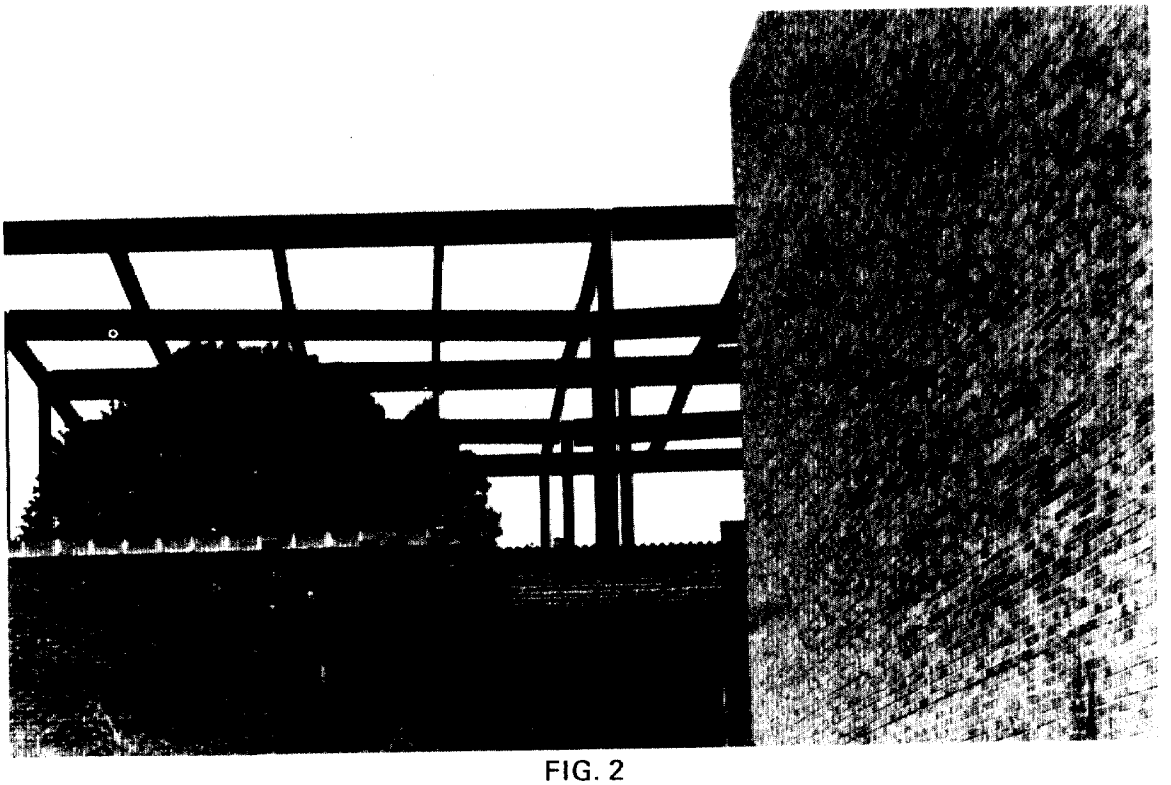


FIG. 2

ABANDONED HARMONY ELEMENTARY SCHOOL
BELLEVILLE, ILLINOIS

FIG.3

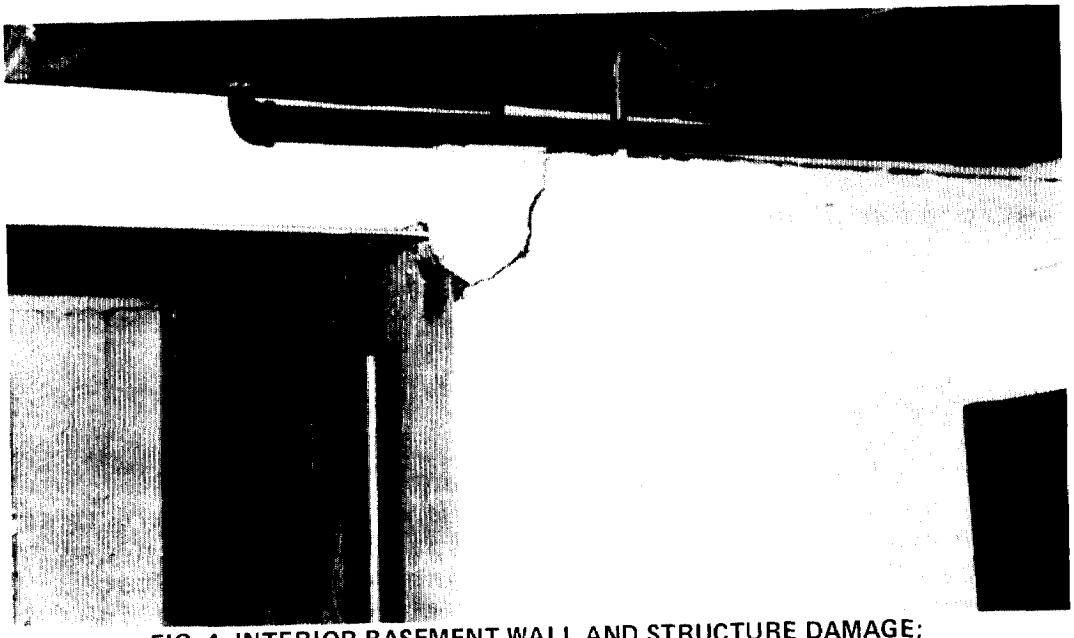


FIG. 4 INTERIOR BASEMENT WALL AND STRUCTURE DAMAGE; ADDITIONAL SUPPORT COLUMNS INSTALLED BY HOMEOWNER

FIG. 5 EXTERIOR CONCRETE PORCH CRACK EXTENDS THROUGH BASEMENT FOUNDATION WALLS

A retired homeowner told us he spent over $8,000--his life savings--repairing past subsidence damage and could not afford further repairs due to limited resources and lack of insurance and financial assistance. He is ineligible for State subsidence insurance until he repairs present damage. As a result, he is unable to sell his home without sustaining a substantial loss.

Figure 6 on page 13 shows a subsidence-damaged Belleville home. This 10-year old ranch-style home, valued between $50,000 and $60,000, represents damage suffered by many homes in the same development since 1975. The suburban development was constructed in a known undermined area.

Pennsylvania

Pennsylvania suffers more subsidence damage from underground abandoned coal mines than any other State. Over 2,000 incidents were reported in the anthracite region and hundreds more were noted in the bituminous region. State actions started in 1909 and in 1961 a mine subsidence insurance program was initiated. This voluntary program currently protects property values of $288 million for 10,000 policyholders and paid claims totaling over $2 million through 1978. Repair costs on recent claims averaged about $5,000 per home. State officials told us that only about 3 percent of those homeowners in subsidence prone areas are insured. Also, many subsidence damage incidents have gone unreported for fear of loss in property value. Subsequent legislation protected existing bituminous region homes (1966) and required subsurface investigations before public school construction in subsidence prone areas (1972).

Active mining is also creating bituminous region subsidence problems and damage. Coal mine owners/operators reimbursed 264 property owners $1.1 million from 1966 to 1977 for such damage. A local official believes that the above understates Pennsylvania's subsidence problem since, in some instances, unprotected homeowners are reluctant to report subsidence damage.

Figure 7 on page 14 shows two southwestern Pennsylvania homes which sustained considerable damage when an 80-foot diameter area subsided between them in June 1968. According to a report on subsidence damage

--one foundation corner dropped following crackling sounds causing a 2-foot opening between the basement and first floor. Within 12 hours, the gap

DAMAGED RESIDENCE--BELLEVILLE, ILLINOIS

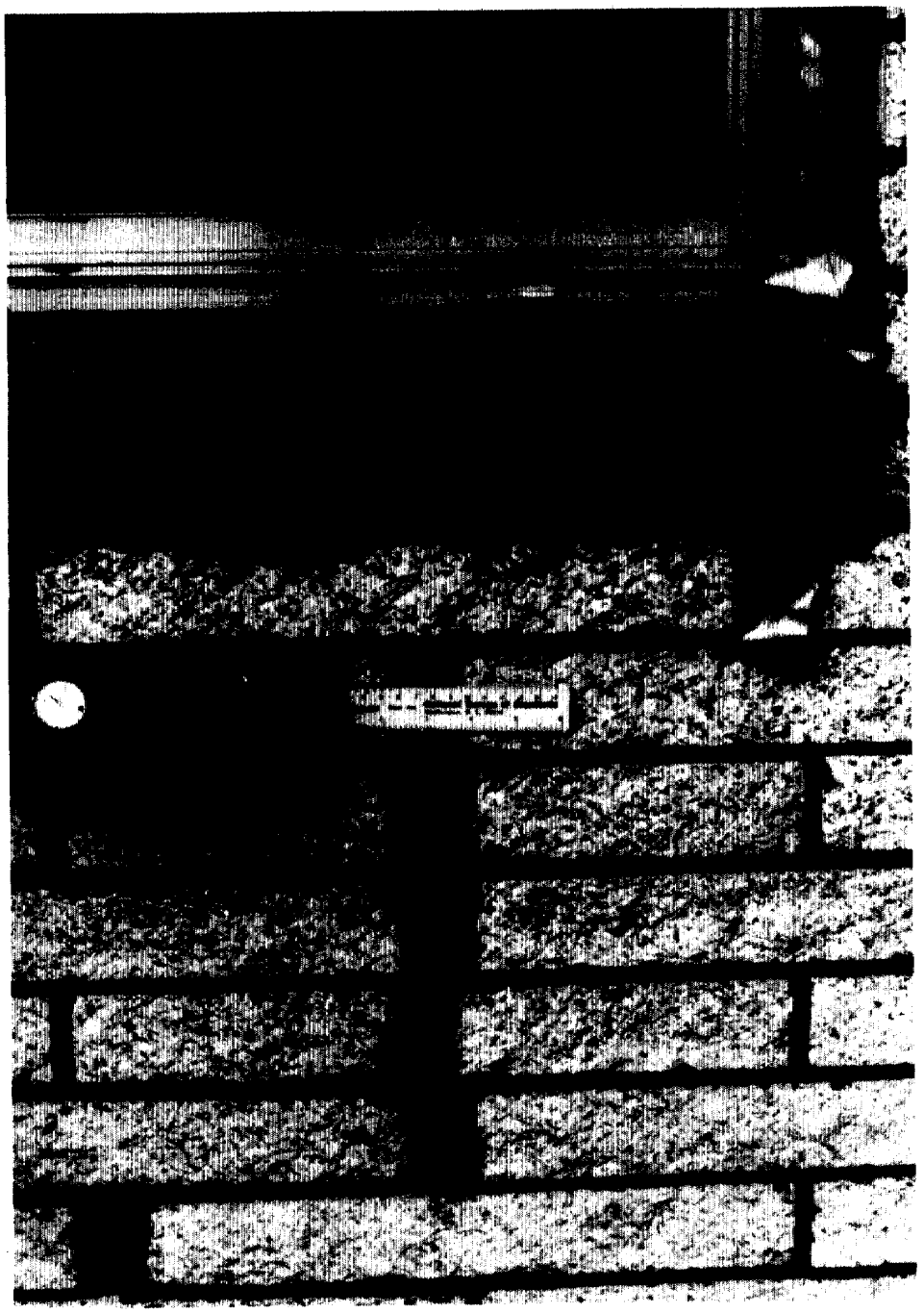


FIG. 6 EXTERIOR BRICK WALL SEPARATION

FIG. 7 TWO HOMES DAMAGED BY SUBSIDENCE

SOUTHWESTERN PENNSYLVANIA

widened to 5 feet and street cracks appeared 25 feet away and

--the neighbor's garage and driveway settled 1 foot and residents within 200 yards of the distressed homes were evacuated. Both homes were located only 30 feet above a mine abandoned 50 years earlier.

Figures 8 and 9 on pages 16 and 17, respectively, show a Belle Vernon junior high school gymnasium and shop area which experienced damage. Tension cracks as wide as 2 inches developed across the north end of one room, the base of one column cracked, and the top of an outside wall buckled. The northeast corner of the 10-year old building settled about 6 inches. The subsided area measured 160 by 190 feet and affected about one-third of the two-story brick building. Movements continued sporadically for several months. The depression gradually broadened and after 7 months reached and damaged the newly completed elementary school 75 feet away. (See fig. 10 on p. 18.)

We visited a backfilling project at Swoyersville where one residence was inundated with coal slurry from the project and was uninhabitable, others had cracked foundations and structural damages, and roads and lawns exhibited pothole subsidence features. A portion of the uninhabitable house foundation settled 12 feet, all utilities were severed, a foundation wall collapsed, numerous cracks appeared in plaster walls throughout the house, and the sides of the house were bowed inward.

Federal and State officials told us that subsidence damage incidents have been reported above abandoned zinc mines in Palmerton and Allentown, Pennsylvania. Such damage is not covered by the State's mine subsidence insurance program or State laws which pertain only to coal mine subsidence.

Ohio

Collapsing abandoned underground coal mine shafts pose a serious problem in the Youngstown, Ohio, area. Subsidence incidents, before a Youngstown resident's garage floor collapsed in June 1977, were few and occurred in remote areas. Additional shaft collapses on two other residential and two school properties prompted State action.

Youngstown condemned and sealed the shaft which destroyed the garage at an estimated cost of $40,000. (See fig. 11 on p. 19.) The State requested Federal financial assistance to remedy the public hazards created by the other shaft collapses.

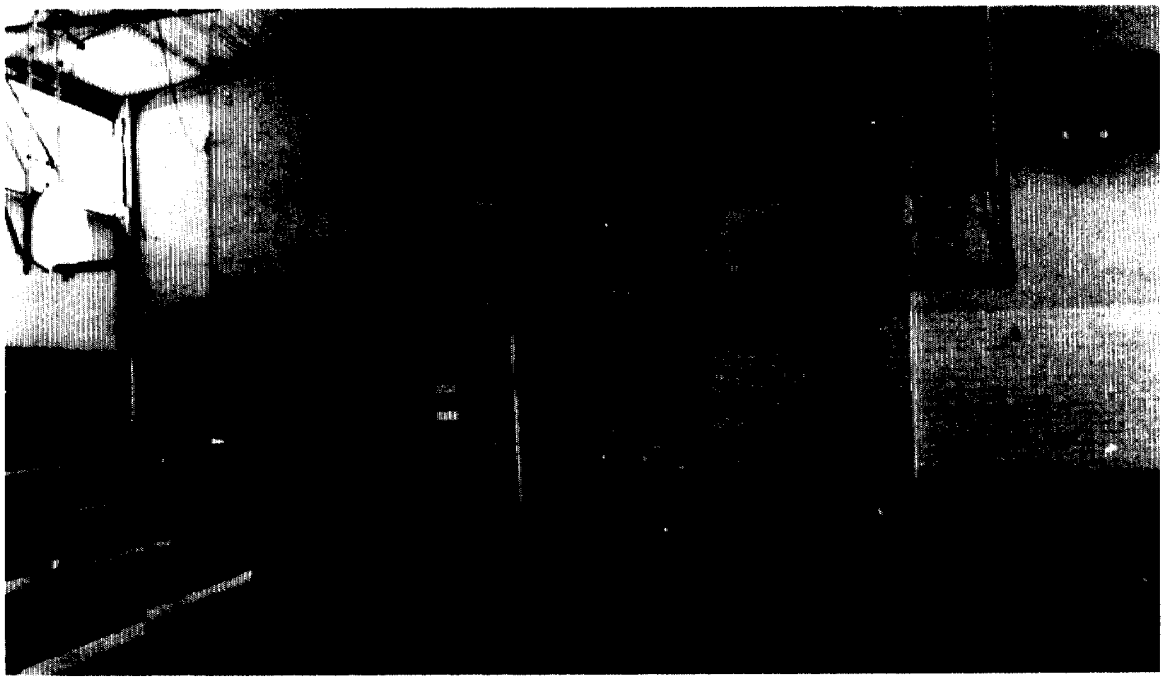


FIG. 8 DAMAGED SCHOOL GYMNASIUM
BELLE VERNON, PENNSYLVANIA

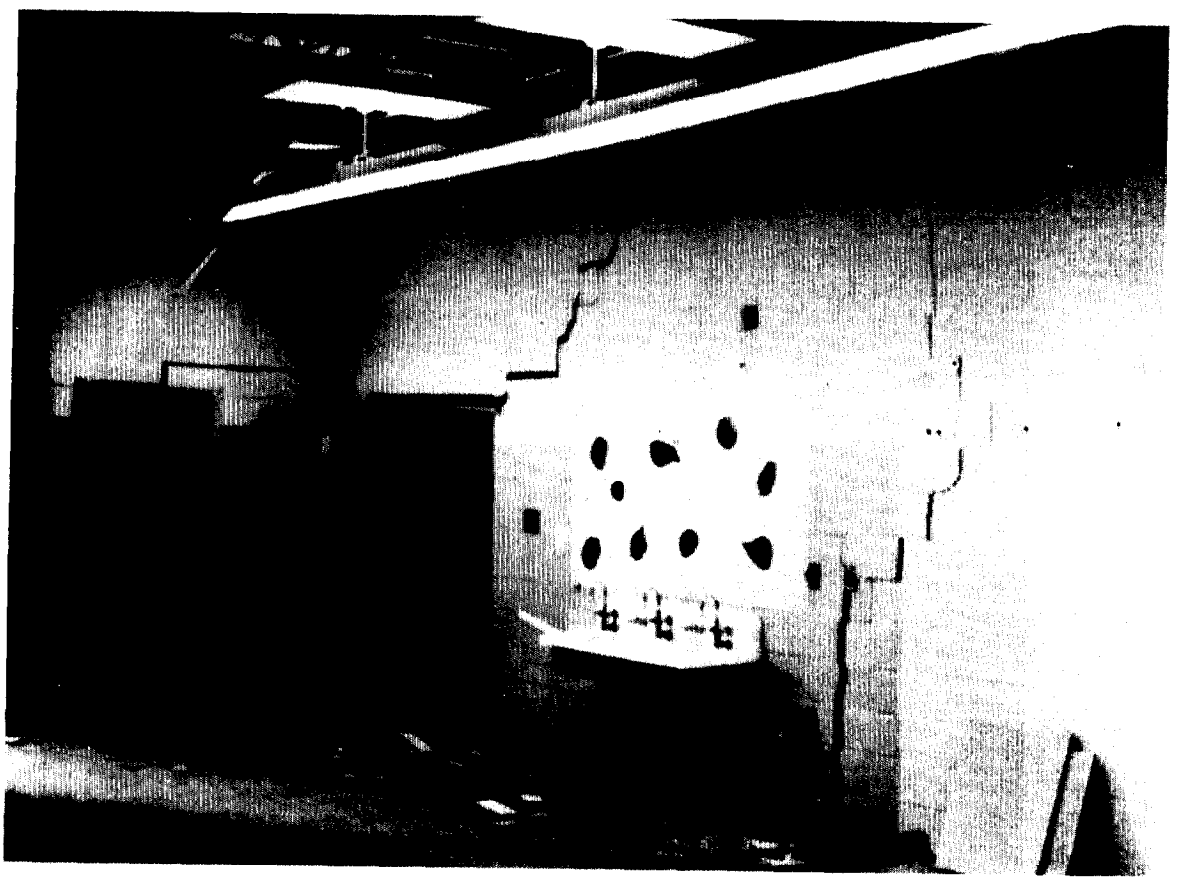


FIG. 9 DAMAGED SCHOOL SHOP AREA
BELLE VERNON, PENNSYLVANIA

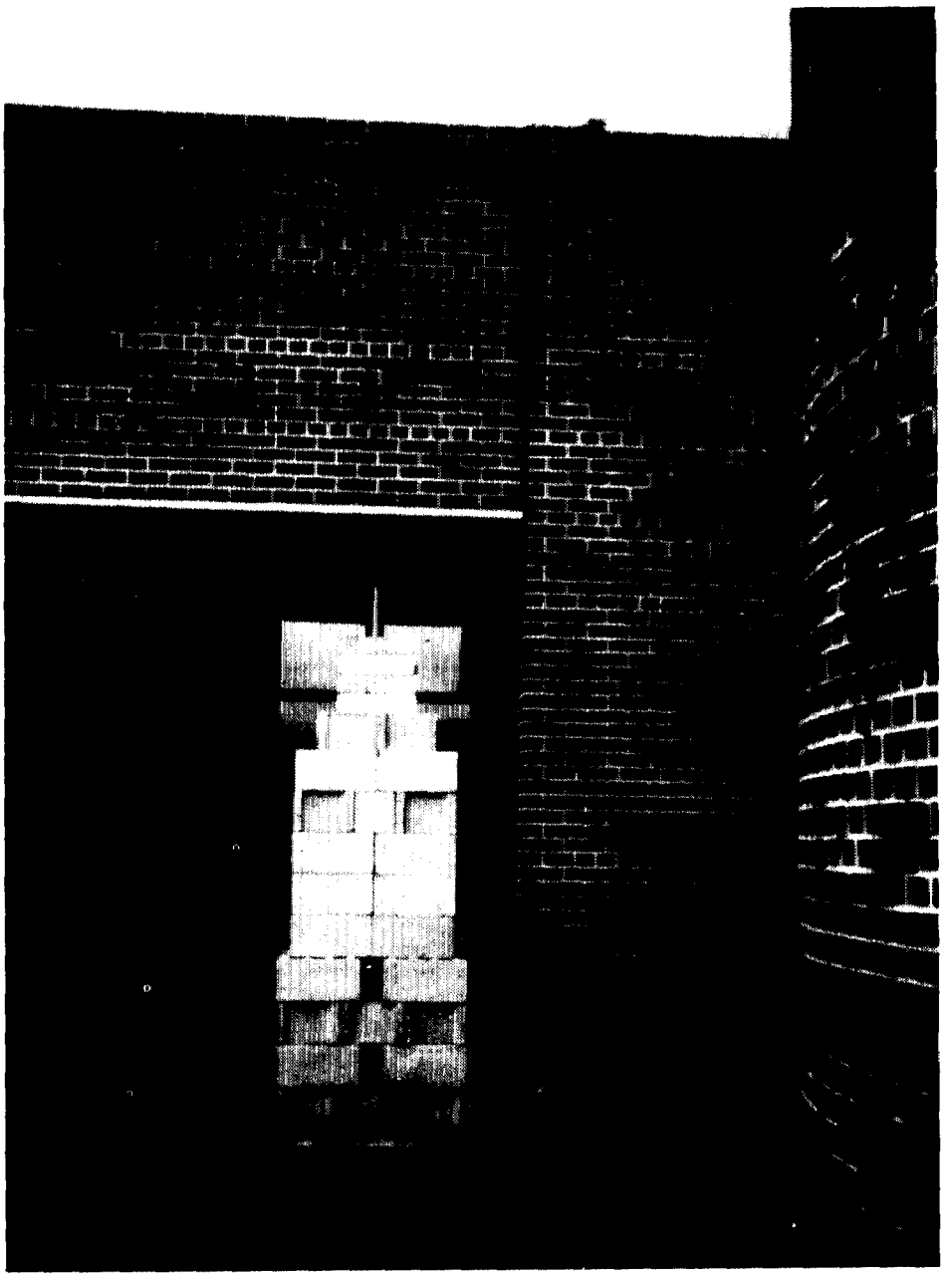


FIG. 10 ADJUSTABLE PROP INSTALLED AT ELEMENTARY SCHOOL BELLE VERNON, PENNSYLVANIA

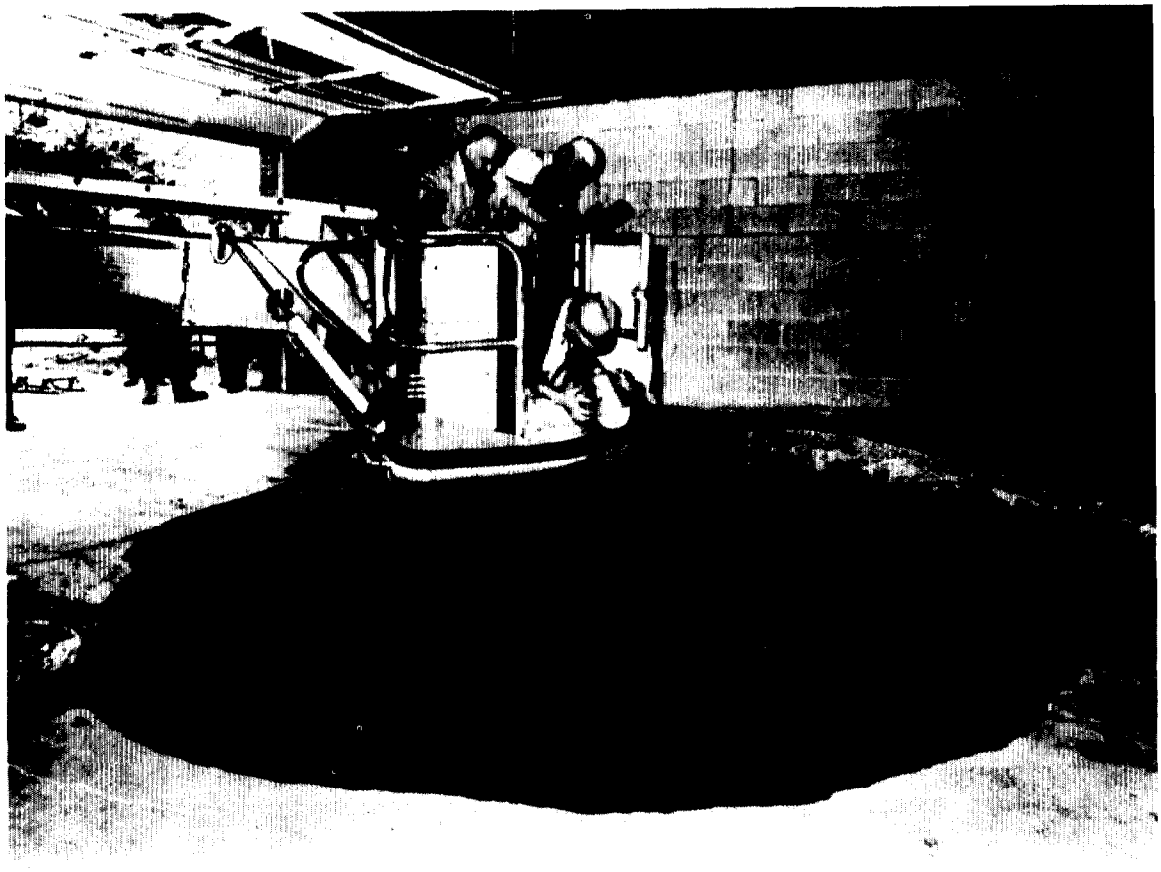


FIG. 11 CONCRETE GARAGE FLOOR DESTROYED
BY COLLAPSED MINE SHAFT OPENING
YOUNGSTOWN, OHIO

West Virginia

Mine subsidence surface damage to houses and structures is most acute in the northern part of West Virginia--especially the town of Farmington in Marion County. Surface disturbances attributed to mine subsidence damaged several homes, churches, commercial buildings, utility lines, and a high school in Farmington. In total, 43 structures were affected by subsidence during a 7-month period starting in October 1973. Twenty-five sustained various misaligned doors, cracked steps, fallen chimneys, and interior and exterior masonry cracks.

Figure 12 on page 21 shows the damaged and abandoned Farmington high school with a large steel buttress constructed to prevent exterior wall collapse. We also observed several damaged homes in the same area.

In Fairmont we observed new homes under construction over an undermined area. (See fig. 13 on p. 22.)

New Jersey

Collapsing abandoned underground iron mine shafts are a localized subsidence problem in the northern area of New Jersey where there are over 400 abandoned mines. State officials estimated that two or three subsidence damage incidents occur annually, with repair costs averaging $15,000 each.

We observed some abandoned open mine shafts and subsidence damage including exterior and interior damage caused by mine shaft collapses under a Dover residence. The homeowner spent over $5,000 repairing subsidence damage to the home.

Kansas/Missouri/Oklahoma

The collapse of improperly filled abandoned lead and zinc mine shafts has caused mine subsidence damage in this tri-State area. Federal, State, and local officials, however, do not believe that mine subsidence is a major problem for the following reasons:

--The overburden supporting the surface is stronger than that found over coal mines.

--Lead and zinc mines tend to be deeper and narrower than coal mines reducing subsidence damage potential except in Oklahoma.

FIG. 12 DAMAGED AND ABANDONED HIGH SCHOOL BUILDING
WITH EXTERIOR STEEL SUPPORT BRACING
FARMINGTON, WEST VIRGINIA

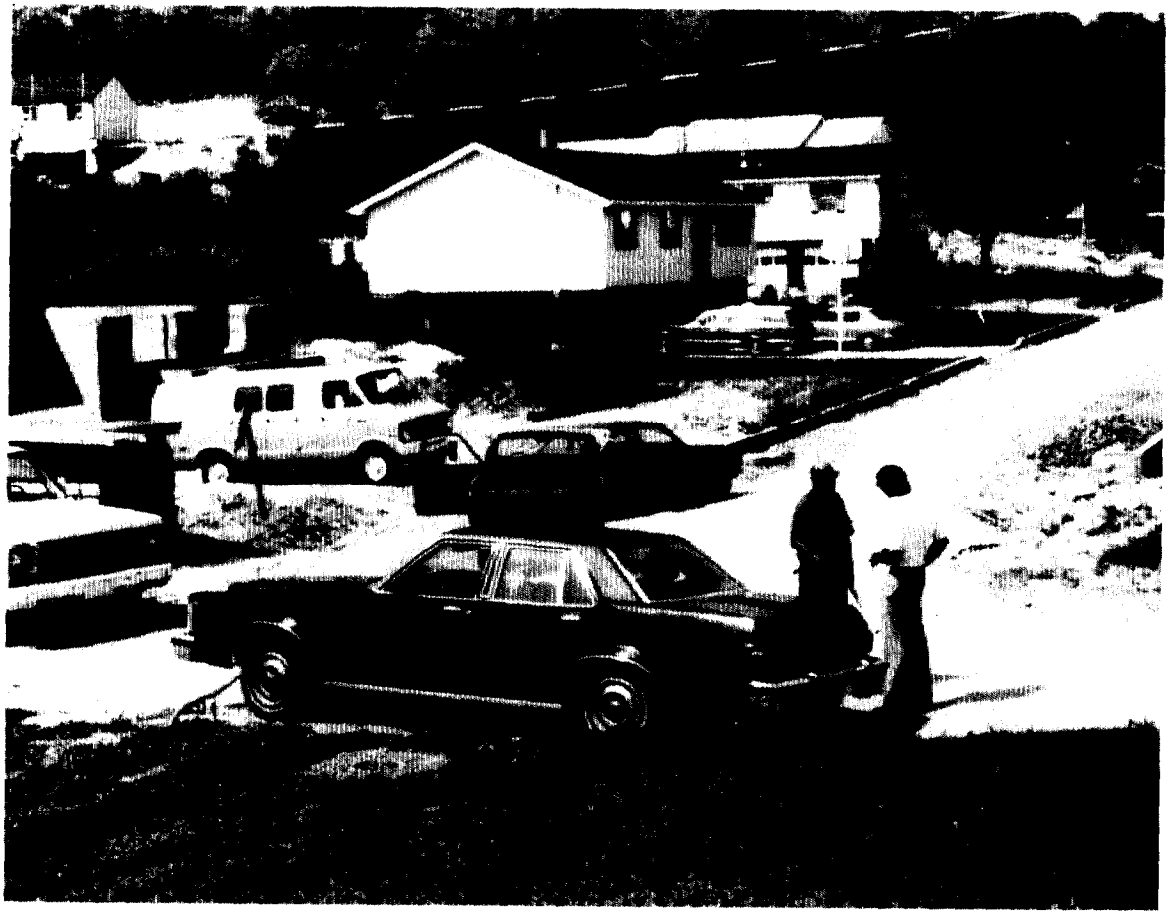


FIG. 13 NEW HOMES CONSTRUCTED OVER UNDERMINED AREA
FAIRMONT, WEST VIRGINIA

--Most subsidence incidents occur in open undeveloped areas.

We visited subsidence-damaged areas at Joplin, Carthage, and Webb City, Missouri; and at Picher, Oklahoma, where inadequate support left by mining companies subsided the surface.

Psychological effects

We identified some homeowners suffering subsidence damage who expressed fear, confusion, and frustration at the slow progressive damage that subsidence caused to their homes. According to a HUD contractor report, such adverse psychological effects are caused by exposure to death or physical injury and by the real or potential economic impact of continuous maintenance costs or the likelihood of losing a major financial investment such as a home. Some homeowners would not allow us to photograph their subsidence-damaged homes, fearing the adverse economic effects, such as loss in property value, that might result from disclosing such conditions.

Illinois State officials told us some homeowners tend to conceal subsidence damage or repairs to avoid such adverse effects. They also told us that to protect unsuspecting buyers in such circumstances, Illinois passed the Consumer Fraud Act providing legal recourse against a homeowner who conceals subsidence damage or an overburden problem in selling his home.

Some Federal, State, and local officials told us that the public often views subsidence as a hazard that must be accepted as a way of life, and in many instances does not acknowledge the problem openly for fear that revealing the condition may adversely affect the community or an individual property owner.

CONTROLS

Regulatory measures and mining methods have been applied in attempts to control subsidence.

Regulatory measures

Federal

The Anthracite Mine Drainage Control Act of 1955 (30 U.S.C. 571 *et seq.*) as amended, authorizes the Secretary

of the Interior to participate with the Commonwealth of Pennsylvania in projects sealing abandoned coal mines and filling abandoned coal mine voids where such work is in the interest of public health and safety. The act requires equal project funding by the Federal and State governments.

The Appalachian Regional Development Act of 1965 (40 App. U.S.C.) provides Federal funds for subsidence control demonstration projects in the 13 Appalachian Regional Commission States. Three of the States--Pennsylvania, West Virginia, and Maryland--have received funds for backfill projects to minimize subsidence damage.

Pursuant to its legal authority, BOM conducts scientific technologic investigations on mining and related problems. Twenty-four subsidence control demonstration projects have been conducted under this authority, including projects in West Virginia, Illinois, Wyoming, and the Pennsylvania anthracite region.

The Surface Mining Control and Reclamation Act of 1977 (30 U.S.C. 1201 et seq.) established a nationwide program to protect society and the environment from adverse effects of surface coal mining operations. The act also deals with the surface effects of underground mining by requiring underground mine operators to

--maximize mine stability,

--seal all unused shafts and holes,

--establish a vegetative cover on regraded or affected lands, and

--provide for special mine drainage systems as well as meet other requirements.

The act provides for filling abandoned mine voids and authorizes the regulatory authority to prohibit or suspend any coal mining which will create an imminent danger to public health and safety. Under the act the Abandoned Mine Reclamation Fund provides revenues supporting the regulatory provisions. The revenues are derived from coal production fees of

--35 cents per ton on surface mining,

--15 cents per ton on underground mining,

--10 cents per ton on lignite coal, or

--a percentage of the coal's value at the mine as determined by the Secretary of the Interior, whichever is less.

OSMRE officials told us that the Surface Mining Control and Reclamation Act of 1977 is not a cure-all for solving subsidence problems. The officials said that the act provides no available mechanism to take care of long term subsidence problems. USGS previously monitored mine subsidence control on Federal lands.

USGS subsidence regulations include part 211 in title 30 of the Code of Federal Regulations requiring mine operators to submit a mining plan showing proposed mining methods and areas and, in some cases, a subsidence monitoring plan. USGS officials told us that the Federal underground coal mining leases monitored by USGS are for mines located mostly in rural areas where little or no surface development has occurred. The Office of Surface Mining Reclamation and Enforcement will have subsidence control authority on all lands under changes resulting from the Surface Mining Control and Reclamation Act of 1977.

State

Most mining States issue permits to mine operators and monitor their mining operations for compliance with State laws, regulations, and other requirements. These procedures, however, are directed to miner health and safety rather than subsidence control. The States require that a mining plan be approved before a mining permit is issued. The plan, among other things, must specify the mining method to be used and possible resulting surface effects from mining.

Pennsylvania's permit procedures require bituminous coal abandonment measures to support surface structures existing in 1966. (See p. 5.) The Pennsylvania Bituminous Mine Subsidence and Land Conservation Act of 1966 provides that pillars be of adequate size, no mining take place under a protected structure where the overburden is less than 100 feet, and no pillars be extracted between two support areas where the distance between the support areas is less than the depth of cover. The act makes coal mine owners/operators responsible for subsidence damage to protected structures from active underground coal mining.

Pennsylvania also took action to protect public school buildings from subsidence damage. In 1972, the State amended the public school building code to require subsurface evaluations before school construction in subsidence prone areas.

Local

Local governments or communities can exercise some control over subsidence through special ordinances or restrictions. For example, Madisonville, Kentucky, adopted an ordinance prohibiting active coal mining beneath the town. Officials stated that mine operators have abided by the ordinance. We also observed under the "home rule" form of government in New Jersey, local planning boards control land development and can require developers to take adequate measures to avoid subsidence damage to surface structures over undermined areas.

Mining methods

Mining methods may limit future subsidence effects. These methods fall into two general categories--mineral abandonment and calculated mining techniques. Mineral abandonment provides the most effective subsidence prevention method by leaving coal resources intact to support surface structures. Abandoning coal resources, however, conflicts with the Nation's increased coal production emphasis as a means to relieve our dependence on foreign energy sources.

Partial extraction systems are forms of mineral abandonment which attempt to reduce subsidence effects by limiting the extraction area's size while leaving some coal resources for support. Disadvantages with this method also exist. According to a 1977 Office of Technology Assessment contract report, partial coal extraction is not always a successful subsidence control measure. Much mine subsidence damage occurred in Pennsylvania although the mine operators' partial extraction mining methods were required to conform to State support regulations.

Government and industry officials believe that, when possible, calculated mining techniques using total extraction mining methods with mine roof collapse followed by surface development are the optimum subsidence damage prevention procedures. Longwall mining achieves the highest extraction rate with essentially concurrent overburden collapse.

Longwall mining is generally more efficient than room and pillar mining. It uses more specialized equipment and fewer miners and provides a greater safety factor. The equipment works against a wide coal panel or extraction face removing coal while supporting the mine roof along the panel face. As coal is removed and conveyed from the face,

the equipment advances allowing the mine roof to cave or collapse in the mined-out area behind it. This mining technique is illustrated on page 28. Longwall mining is widely used outside the United States because of poorer natural conditions, and the limited distribution and accessibility of coal reserves.

Converting the U.S. coal industry to the longwall mining method, however, may be economically and geologically impractical or environmentally unacceptable. The equipment is very costly and cannot be financed by the small mine operators. Also, in some areas coal seams are not sufficiently uniform to effectively use this method. This mining technique is adaptable where the coal seam is fairly uniform in thickness.

Other total extraction mining methods use harmonious, panel, and pillar mining techniques which calculate and create subsidence movements in a controlled manner so as to reduce surface displacement and, therefore, damage. To predict or control the effects of mining-induced subsidence, however, it is necessary to define subsidence parameters by conducting accurate systematic surveys of horizontal and vertical displacements. According to a private consultant firm, such information is limited in the United States, and without accurate information definite conclusions cannot be reached concerning the benefits of subsidence prediction and control techniques. Most Federal, State, and local officials we interviewed expressed similar views. OSMRE officials told us, however, that one major coal company can predict the degree of subsidence with up to 90 percent accuracy.

CONCLUSIONS

The collapse of underground abandoned mines causes the greatest damage to private and public buildings in Pennsylvania and Illinois. Future surface damage from subsidence can be further controlled or minimized by using new mining methods. The best method is total extraction with essentially concurrent mine roof collapse which results in two advantages:

--Surface development can take place sooner after mining with less fear of future subsidence damage.

--Almost all the coal can be extracted which will help in the Nation's efforts to rely more on domestic energy sources.

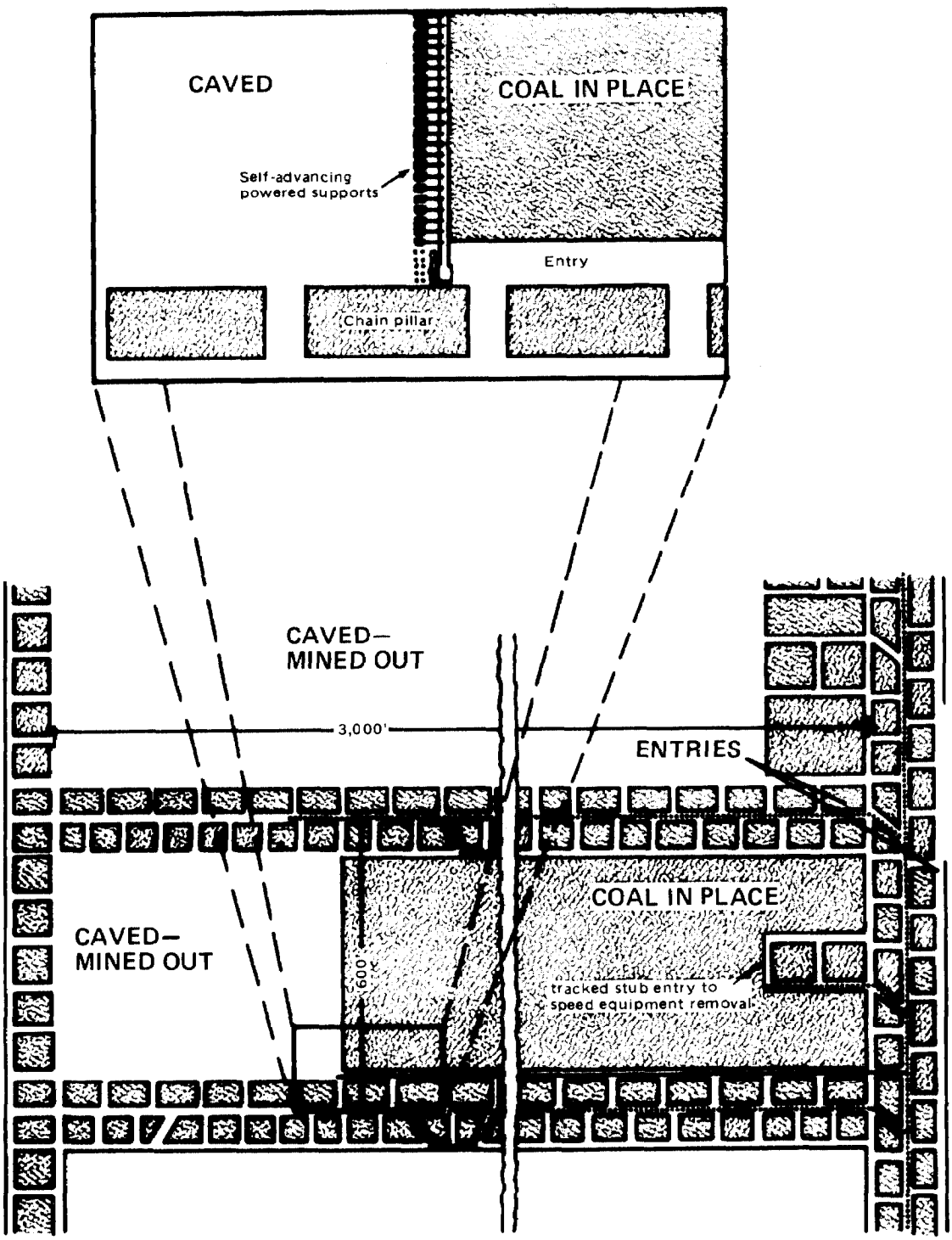


FIG. 14 EXAMPLE OF LONGWALL MINING

Before this method can be widely applied, however, more information is needed on

--potential locations where underground mining will occur and

--whether longwall or other total extraction mining methods can be used.

There is also a need to systematically collect and analyze subsidence data essential to determine the real or potential subsidence impact nationwide. Such data is basic to policy development at the national level and is useful for planning and development purposes.

RECOMMENDATIONS TO THE SECRETARY OF THE INTERIOR

We recommend that the Secretary of the Interior

--develop information on total extraction mining methods and applications with controlled subsidence;

--promote using such methods where possible when discharging mining oversight responsibilities with States and coal mine operators;

--establish a centralized mechanism for collecting, analyzing, and coordinating data essential for assessing subsidences' nationwide impact; and

--develop remedies to solve the problem, considering the alternatives we identified.

CHAPTER 3

ALTERNATIVES FOR MINIMIZING ECONOMIC EFFECTS OF SUBSIDENCE

The financial burden of repairing subsidence damage could be disastrous to property owners. Property owners generally cannot recover repair costs from underground mine operators, especially abandoned mine owners, and are victims of circumstances beyond their control.

No Federal program protecting property owners from the financial effects of subsidence damage exists, and only Pennsylvania and Illinois have enacted mine subsidence insurance programs.

We identified the following possible alternatives which may protect the property owner from severe financial hardship

--insurance programs,

--Federal and other aid,

--land use controls,

--building standards and preventive measures, and

--filling mine voids.

The major advantages and disadvantages of each alternative are discussed below.

INSURANCE PROGRAMS

Currently, only State insurance programs in Pennsylvania and Illinois and the National Housing Association's Home Owners Warranty Program provide direct financial relief to property owners.

Pennsylvania's mine subsidence insurance program established in 1961 covers direct losses (damages to the insured structure) caused by lateral or vertical subsidence resulting from past or present coal mining operations. It is a voluntary program subsidized and administered by the State. Homeowners may purchase $5,000 to $50,000 coverage for annual premiums ranging from $15 to about $51, respectively. Commercial property owners may purchase $50,000 maximum coverage for $200 annually. Subsidence

damage reimbursement is based on repair cost estimates less a $250 flat deductible for residential properties and $500 for commercial properties.

The major program shortcoming is lack of participation; experts said that limited advertising coupled with public apathy hinders the program as a comprehensive subsidence prevention tool.

Illinois enacted a State mine subsidence insurance program effective October 1979 which

--mandates that subsidence insurance be made available for any structure in subsidence prone areas at a rate which will satisfy foreseeable claims by companies authorized to write basic property insurance,

--uses the existing commercial insurance companies to receive premiums and pay claims, and

--provides total coverage up to $50,000.

The National Association of Home Builders developed the Home Owners Warranty Program to serve the home buyer's best interests. The program is a voluntary 10-year home buyer protection plan whereby the builder warrants the workmanship, material, and structure for the first year and continues to warrant the electrical, plumbing, heating, and cooling systems against major structural defects during the second year. Protection against major structural defects during the last 8 years is provided by a national insurance plan underwritten by an insurance company. Structural defects due to settling, expansion, or soil movement including subsidence, are covered by the program.

Advantages	Disadvantages
Provides direct reimbursement to homeowners.	Insurance programs do not provide relief for homes already affected by subsidence.
Coincides with State and local officials' opinions that States should resolve subsidence problems.	May only be applicable in undermined areas with a broad insurance risk base.

FEDERAL AND OTHER AID

Federal and other aid could be provided homeowners by

--classifying subsidence a disaster requiring emergency relief or

--creating and funding Federal and other mine subsidence programs.

Subsidence--a disaster

Currently, home and commercial property owners are eligible for financial relief from floods, earthquakes, tornadoes, and hurricanes. Including subsidence as a disaster may provide property owners similar relief.

Property owners suffering subsidence or natural disaster damage are unknowing victims. They are unable to control or predict the disaster. Yet, subsidence victims in most underground coal mining States generally have no financial recourse.

Advantages	Disadvantages
Providing financial relief for disasters is an established precedent.	Inclusion may be difficult since subsidence is manmade and not a natural disaster.
	Expertise required to monitor the program may not be available on a national basis.

Federal and other mine subsidence programs

Creating a Federal mine subsidence program requires a funding source. Currently, coal producers pay production taxes for reclamation as required by the Surface Mining Control and Reclamation Act of 1977. However, this excludes reimbursement to property owners for subsidence damages. Increasing the underground coal producers' tax by $0.09 per ton would provide funds required to repair the estimated $30 million annual subsidence damage; $0.02 per ton would be needed to repair the estimated $6 million annual residence damage. (See p. 7.)

Advantages	Disadvantages
Coal producers are already providing the funds to correct environmental damage created by mining.	Increased consumer costs.
	May provide surface coal operators a competitive edge. Officials indicated that producers are currently having problems competing with western surface coal and any additional tax may tip the scales.

A Federal subsidence program could also be funded by charging the energy consumer a users tax to fund Federal subsidence relief. Consumer coal demand provides the profit incentive to mine and that demand may cause future subsidence problems.

Advantages	Disadvantages
Consumer paying for damage created by demand.	Increased cost to the consumer.
	Implementation and administrative problems.

States could also establish mine subsidence programs to protect property owners. One means is through protective legislation. For example, Pennsylvania's Bituminous Mine Subsidence and Land Conservation Act of 1966 requires bituminous coal abandonment measures to protect surface structures existing in 1966. The act makes coal mine owners/operators responsible for subsidence damage to protected structures caused by active underground coal mining. (See pp. 12 and 25.)

Financial relief or aid for repairing subsidence-damaged properties could also be provided under State-funded programs.

Advantages	Disadvantages
May limit subsidence damage and severe financial effects.	May increase consumer costs or State taxes.
Does not require Federal funds.	May require resolution of legal problems on property rights.

LAND USE CONTROLS

Regulating subsidence vulnerability through land use controls include zoning and subdivision regulations. Other approaches include public improvements, tax incentives, and special insurance requirements.

Cities and counties use zoning to control building location and design characteristics in developing specified areas or districts. Subdivision regulations apply whenever a property owner proceeds to subdivide land parcels for sale or development. These regulations normally require land owners to submit a land map showing subdivision boundaries and road easements, utilities, and public facility locations to a local governing body or planning body. To date land use controls have not been used to protect property owners in subsidence-prone areas.

Land use controls are feasible over abandoned, active, and potential coal mining areas. The optimum land use subsidence control solution is a combination of zoning, subdivision regulation, and mining method so as to mine, subside, then develop. By causing subsidence to occur during the mining phase or shortly thereafter, future subsidence damage is avoided. Most local and State officials believe that restrictive zoning, if implemented, would tend to reduce growth potential.

Advantages	Disadvantages
Most effective subsidence damage prevention measure.	Contradicts public land development attitudes.
	Effectiveness depends on local government ability to enact and enforce zoning laws and ordinances that are acceptable to the public.

BUILDING STANDARDS

Building codes or construction standards provide for government control of building design and construction. Special design criteria are applied to homes constructed in flood plains or earthquake-prone areas. Criteria for subsidence-prone areas exist but have not yet been applied.

Except for occasionally using slab foundations, little has been done in the United States to minimize subsidence damage through design or preventive measures. New construction design subsidence preventive measures include

--prospective building site analysis,

--flexible designs such as concrete slab,

--independent building units with releveling jacks and gap provisions, and

--small box form houses.

Existing buildings require individual study to determine the economics involved and preventive measures advantageous to their needs. Some preventive methods for existing buildings include:

--Digging a trench 1 yard away from surrounding walls and below the foundation and filling with compressive materials.

--Cutting buildings and brick walls to relieve compression and tension.

--Taping large glass windows.

--Using arch supports and wall shoring.

--Reinforcing or jacking.

Advantages	Disadvantages
May limit subsidence damage and severe financial effects.	May be difficult to gain support from construction industry and public.
May cost less than subsidence damage repairs in certain instances.	Cost may be prohibitive in certain instances.

FILLING MINE VOIDS

Artificial support projects are designed to prevent or reduce future subsidence over abandoned mines by filling mine voids. Mine void filling methods vary in their approach, completeness of fill, and backfill material.

Backfilling costs vary significantly from method to method and, in some cases, exceed the supported surface property value. A BOM official told us that the cost to backfill 1 acre of land increased from about $10,000 in 1973 to $22,000 in 1978. The cost is even greater to backfill anthracite mines because of multiple seam mining.

According to an Appalachian Regional Commission report, surface stabilization should permanently eliminate any subsidence movement, but this goal is seldom achieved. Realistically, surface stabilization either reduces or postpones subsidence movements. The report further concluded that the relative project effectiveness is based largely on conjecture. Little or no onsite testing or long-term observations have been conducted in active subsidence areas. Backfilling is the Federal Government's response to the subsidence problem. The Government approved about $72 million for artificial support (backfill) projects in fiscal years 1965-78--$46 million by the Appalachian Regional Commission and $26 million by BOM. Pennsylvania officials told us that the State has spent millions of dollars for backfilling projects.

Officials in Pennsylvania, the primary project State, either questioned or praised this measure's preventive effectiveness. State mine subsidence insurance officials stated that it was a temporary procedure, does not guarantee subsidence protection, and may initiate subsidence damage. BOM officials and a Pennsylvania Department of Environmental Resources official stated, however, that backfilling was the optimum subsidence preventive solution for abandoned mines.

Advantages	Disadvantages
Decreases the degree of subsidence and, therefore, damage.	May be economically prohibitive. For example, a 1942 artificial support estimate for the Pennsylvania anthracite region totaled $7 billion and was not approved.
	Is not a permanent solution or guarantee against subsidence damage.
	May initiate subsidence.

CONCLUSIONS

To date, land use controls or construction standards have not been used to protect homeowners in subsidence-prone areas. Regulating mining methods and supporting the surface artificially are the predominant subsidence damage prevention measures.

Programs such as the Home Owners Warranty Program on new construction and Pennsylvania's State subsidence insurance program and Pennsylvania's Bituminous Mine Subsidence and Land Conservation Act of 1966 program have been the only means of direct reimbursement to homeowners for subsidence damage.

The Federal Government and Pennsylvania have spent millions of dollars to stabilize the surface through backfilling projects. These projects are extremely costly and may not always be successful in preventing subsidence. Many property owners have been or will be victims of subsidence damages through no fault of their own and, consequently, will have to bear the financial burden of repairing their property. Some alternatives for providing relief to property owners include:

--Promoting State mine subsidence insurance programs.

--Covering homeowners under the Federal Disaster Relief Act.

--Modifying the Surface Mining Control and Reclamation Act of 1977 to cover subsidence damage through a production tax on underground coal mining.

--Creating a Federal subsidence program funded by an energy use tax charged to consumers.

APPENDIX I

URBAN AREAS SUBJECT TO POTENTIAL SUBSIDENCE PROBLEMS RESULTING FROM UNDERGROUND MINING OPERATIONS

Urban areas listed below are those areas which are in proximity to various types of underground mining activities and which are subject to potential subsidence problems.[1]

Alabama	- Coal and iron mines: adjacent to Birmingham.
Arizona	- Copper mines: Bisbee and Jerome.
Arkansas	- Coal mines: Hartford, Montana, Paris and Spadra.
Colorado	- Coal mines: Dacona, Firestone, Frederick, Lafayette, and Louisville. Lead-zinc mines: Leadville.
Idaho	- Gold, silver, lead and zinc mines: Burke, Gem, Kellogg, Mullan, Murray and Smelterville.
Illinois	- Portions of cities and towns probably underlain by mines include: Belleville, Benton, Breeze, Carbondale, Centralia, Collinsville, Danville, Decatur, Edwardsville, Harrisburg, Herrin, Johnston City, Marion, Maryville, Mount Vernon, Springfield, Streator, West Frankfort, and Ziegler. Lead-zinc mines underlie Galena.
Indiana	- Coal mines: Ashboro, Augusta, Boonville, Brazil, Buckskin, Carbon, Centerpoint, Chandler, Dugger, Evansville, Fort Branch, Francisco, Gibson, Hymera, Kings, Knightsville, Linton, Newburgh, New Goshen, Petersburg, Seelyville, Terre Haute, and Yankeetown.
Iowa	- Coal mines: Boone, Centerville, DesMoines, Knoxville, Oskaloosa, and Ottumwa.

[1] U.S. Department of Interior, Bureau of Mines, Final Environmental Statement: Surface Subsidence Control in Mining Regions, November, 1976, pp. 23-25.

APPENDIX I

Kansas - Zinc-lead mines: Galena and Treece.
Limestone mines: Kansas City.
Coal mines: Alma, Atchison, Burlingame, Cherokee, Croweburg, Franklin, Frontenac, Lansing, Leavenworth, Mineral, Mulberry, Osage City, Pittsburg, Pleasanton, Scammon, Scranton, Weir, and Williamsburg.
Salt mines: Hutchinson, Kanopolis, and Lyons.

Kentucky - Coal mines: Madisonville.
Limestone mines: Lexington.

Maryland - Dimension stone mines: Cardiff.
Coal mines: Frostburg.

Michigan - Iron Mines: Bessemer, Iron River, Ironwood, Ishpeming, Negaunee, and Wakefield.
Salt mines: Detroit.
Gypsum mines: may be under Grand Rapids.
Copper mines: adjacent to and probably underneath Calumet, Hancock, and Houghton.

Minnesota - Iron mines: Aurora, Biwabik, Chisholm, Eveleth, Hibbing, and Keewatin.

Missouri - Zinc-lead mines: Alba, Aurora, Carterville, Duenweg, Neck City, Oronogo, Purcell, Webb City, and Wentworth.
Lead mines: Anapolis, Bonne Terre, Desloge, Doe Run, Flat River, Leadington, Leadwood, Valles Mines, and Viburnam.
Coal mines: Bevier, Brookfield, Bucklin, Cainsville, Cameron, Carrollton, Clifton Hill, Deepwater, Elmira, Farber, Huntsville, Kansas City, Kingston, Kirksville, Knoxville, Lexington, Macon, Marceline, Melbourne, Milan, Midenmines, Missouri City, Montgomery City, New Cambria, Richmond, St. Louis, Trenton, Vibbard, Waverly, Wellington, Windsor, and Winston.
Clay mines: Deepwater and St. Louis.
Limestone mines: Carthage, Kansas City and Neosho.
Sandstone mines: Crystal City.

Montana - Copper mines: Butte, Centerville, and Walkerville.

Nevada - Gold and silver mines: Tonopah and Virginia City.

New Jersey - Iron mines: Dover, Hibernia, Mine Hill, Ringwood, Rockaway, and Wharton.

New Mexico - Potash mines: Carlsbad

New York - Iron mines: Lyon Mountain, Minesville, and Witherbee.

Ohio - Coal mines: may underlie some urban areas in the southeastern and eastern parts of the State.
Salt mines: Cleveland.

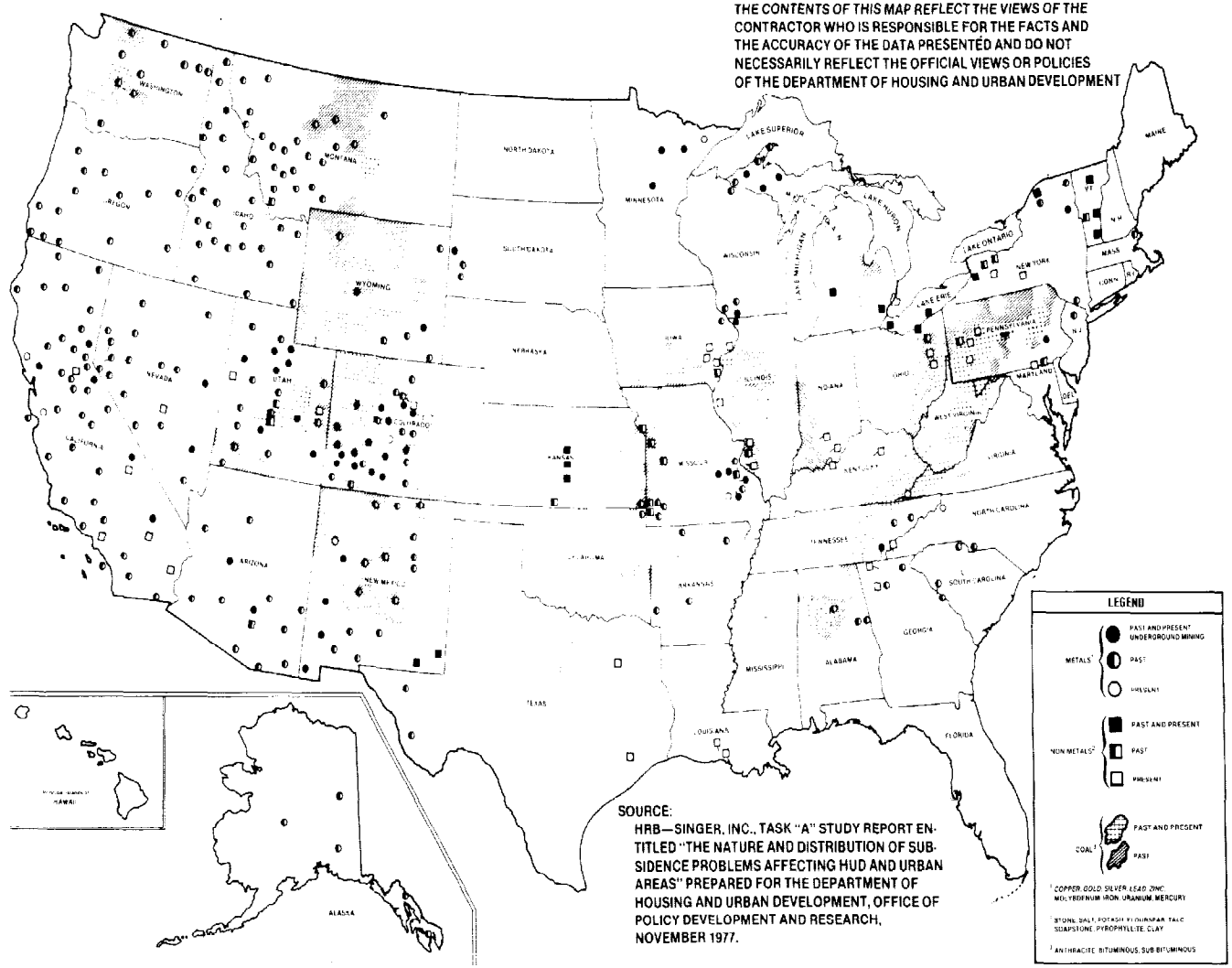
APPENDIX I

Oklahoma	- Coal mines; Bokoshe, Broken Arrow, Coalgate, Coalton, Cottonwood, Dewar, Haleyville, Hartsherne, Henryetta, Krebs, Lehigh, McAlester, McCurtain, Tulsa, and Wilburton. Zinc-lead mines: Cardin, Commerce, North Miami, Peoria, Picher, and Quapaw.
Oregon	- Coal mines: Coos Bay. Iron mines: Oswego.
Pennsylvania	- Anthracite mines: The Anthracite region and particularly the Northern Anthracite field including Scranton and Wilkes-Barre. Bituminous mines: portions of the following urban areas are undermined: Brownsville, Canonsburg, Charleroi, Donora, Johnstown, Metropolitan Pittsburgh, Monogahela, and Uniontown.
South Dakota	- Gold mines: Lead.
Virginia	- Gypsum mines: Plasterco. Coal mines: Norton.
Washington	- Coal mines: Bellingham, Black Diamond, Carbonado, Centralia, Chehalis, Cle Elum, Issaquah, Newcastle, Ravensdale, Renton, Ronald, Roslyn, and Wilkeson. Iron mines: Hamilton. Gold mines: Chewelah, Republic, and Wenatchee. Lead-zinc-silver mines: Leadpoint and Metaline.
West Virginia	- Coal mines: Barrackville, Bartley, Bradshaw, Fairmont, Fairview, Farmington, Grant Town, Monongah, Rivesville, and Welch.
Wisconsin	- Lead-zinc mines: Benton, Hazel Green, Mineral Point, New Diggings, Platteville, Shullsburg, and Tennyson. Iron mines: Hurley and Montreal.
Wyoming	- Coal mines: Reliance and Rock Springs.

APPENDIX II

PAST AND PRESENT UNDERGROUND MINING ACTIVITY [1] BY COUNTY IN THE UNITED STATES

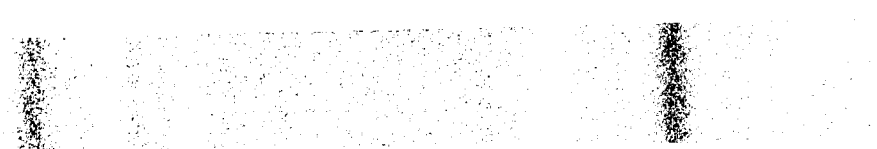
THE CONTENTS OF THIS MAP REFLECT THE VIEWS OF THE CONTRACTOR WHO IS RESPONSIBLE FOR THE FACTS AND THE ACCURACY OF THE DATA PRESENTED AND DO NOT NECESSARILY REFLECT THE OFFICIAL VIEWS OR POLICIES OF THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT



SOURCE:
HRB—SINGER, INC., TASK "A" STUDY REPORT ENTITLED "THE NATURE AND DISTRIBUTION OF SUBSIDENCE PROBLEMS AFFECTING HUD AND URBAN AREAS" PREPARED FOR THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, OFFICE OF POLICY DEVELOPMENT AND RESEARCH, NOVEMBER 1977.

[1] INFORMATION DISPLAYED ON THIS MAP IS GENERALIZED AND IS NOT INTENDED FOR SITE SPECIFIC USE. THIS GAO REPORT OMITS COUNTY BOUNDARIES AND NAMES INCLUDED ON THE STUDY MAP.

(190462)



AN EQUAL OPPORTUNITY EMPLOYER

UNITED STATES
GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE,$300

POSTAGE AND FEES PAID
U. S. GENERAL ACCOUNTING OFFICE

THIRD CLASS