

HURRICANE AGNES—DAMAGE IN PENNSYLVANIA

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•THE DOWNPOUR of Hurricane Agnes was just unbelievable. Agnes sort of crept up on us. It developed near the Yucatan coast on June 19, 1972, but it was not until June 21 that it started dumping rain in Pennsylvania.

The soil at that time was nearly saturated because of the rainfalls preceding Agnes. Almost all of the precipitation turned into surface runoff immediately. The deluge of rain continued into Thursday, June 22. Maximum 24-hour totals exceeded 7 in. in a wide area of central Pennsylvania. Harrisburg had a maximum 24-hour rainfall of 12.55 in.

The Agnes flood levels of 1972 exceeded the previous record of 1936 by 3 to 6 ft in the Susquehanna River. At Wilkes-Barre, Pennsylvania, the river crested 18 ft above flood stage. The Schuylkill River in southeastern Pennsylvania crested at almost 17 ft above flood stage, which was 8 ft above the previous record set in 1902. In western Pennsylvania, the Allegheny, Monongahela, and Ohio Rivers crested at or near record levels.

The overall damage from the June 1972 floods in Pennsylvania is estimated at more than \$4 billion. Damage to roads, bridges, and other transportation facilities is estimated to exceed \$100 million. The flood damage estimate for state roads and bridges, based on PennDOT damage survey reports, is about \$66.3 million. The damage to municipal roads and bridges is reported to be approximately \$24.8 million.

On the state highway systems including federal-aid and non-federal-aid roads, 252 bridges were out of service: 80 had all spans destroyed, 17 had some spans missing, and 155 were severely damaged or had their approaches washed out. More than 370 miles of highway were closed. Of the 252 bridges damaged, 227 or nearly 90 percent were located in the Susquehanna River Basin and in four of PennDOT's 11 engineering districts.

These numbers are for the state highway system only (municipal structures are not counted). As regards municipal structures, approximately 220 bridges were totally washed out and, in addition, 150 bridges were damaged. This is a total of approximately 622 state and local bridges out of service following the June 1972 floods.

Regarding the sizes of the bridges destroyed or damaged by Hurricane Agnes, the following table gives the percentage of bridges in the state highway system that were damaged:

<u>Length of Structure (ft)</u>	<u>Percentage Damaged</u>
<10	7
10 to 19	27
20 to 49	26
50 to 99	21
100 to 199	11
200 to 399	5
>400	3

As soon as the condition of all bridges was known, the Corps of Engineers was requested to remove, from rivers and streams, all destroyed or damaged bridges that obstructed the flow and to erect a total of 18 temporary Bailey bridges throughout Pennsylvania. They have erected 14 Bailey bridges to date; the other four sites are still under study.

From the outset of the disaster, it was recognized that considerable federal aid would be required in the flood recovery effort. Therefore, as soon as PennDOT went on an emergency operation basis, the division engineer for the Federal Highway Administration in Harrisburg was contacted and arrangements were made for carrying out key FHWA functions relating to the flood relief program at PennDOT's emergency headquarters. The FHWA and PennDOT worked out the preliminary details involved in the mechanics of making the damage survey reports and in determining what damages qualified for federal aid.

By June 24, FHWA engineers were on their way to begin the job of making damage survey reports with PennDOT personnel. To get as many teams in the field as soon as possible, FHWA engineers were brought in from other division offices, regional offices, and the Washington office. Approximately 50 FHWA engineers were sent to help conduct the damage surveys on all state highways and local roads. A total of approximately 11,000 reports have been made to date. These reports form the data base for our request for federal relief funds. A total of 7,670 damage survey reports have been completed on state facilities alone.

It is our goal to have most of the replacement bridges under contract by the spring of 1973. Special instructions have been issued to our district offices to cut down on the design time. Also, the Department of Environmental Resources has given high priority to approval of waterway openings in all flood-related projects.

As of the end of December, 214 of the 252 damaged bridges had been repaired or temporary run-arounds constructed and 350 miles of the 373 miles of damaged roadway had been reopened. Also as of that date, 253 emergency contracts were negotiated for a total of approximately \$15 million, and 194 have been completed to date.

No attempt has been made to review in-depth the cause of damage for each bridge. However, through the hydrologic and hydraulic reports submitted to our office for waterway approval, we did find some clues on the causes of the damage. Although the statistics are not available, the causes can generally be grouped into the following categories.

1. Scour at bridge abutments or piers due to poor foundation materials: This type of damage might have been prevented if adequate scour protection devices such as rip-rap protection or spur dikes had been provided.
2. Damage to bridge abutment or approach embankments due to poor upstream alignment (a sharp turn at the bridge site): In this case, some of the bridges might have been saved if they were not constructed at these troubled spots or, in the case of small streams, if channel relocations with smooth upstream alignments had been provided.
3. Debris pile-up: Some bridges lost because of debris might still remain intact if the individual span lengths of the multiple openings were adequate. Some small structures were lost by debris being carried by floodwaters and ramming the structures, e.g., mobile homes, trees.
4. Loss of approach embankments due to shift of channel courses: The shift of the channel courses was probably due to formation of sand bars in the channels and to unstable banks. This was typified in the areas where the streams were artificially widened at the bridge sites.
5. Encroachment of approach embankments or abutments into the main channels of the stream: Several bridges appear to have been lost because of this. The obstructions should not have been placed on the main channel courses.

Without question, many bridges were damaged or destroyed simply because of old-age deterioration of structural components. However, some bridges might have been saved if the hydraulic design were adequate.

The hydraulic science is a relatively new field and many areas of research remain to be addressed. I hope, under the leadership of the Highway Research Board, especially under the guidance of the Committee on Surface Drainage of Highways, more research in the field of hydrology and hydraulics can be performed so that we can design and construct hydraulically sound bridges with total confidence.

In conclusion, I would like to mention that we in Pennsylvania are battered but not beaten by Hurricane Agnes. PennDOT has received many letters of praise for the work of its personnel during the flood. It never fails that when disaster strikes there is something about Americans that makes them come through. The employees of PennDOT and other state and federal agencies proved this conclusively during Hurricane Agnes, and they can be proud of their accomplishments.
