Effects of Hurricanes Katrina and Rita Flooding on Louisiana Pavement Performance

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ABSTRACT: In August and September of 2005, Louisiana was devastated by Hurricanes Katrina and Rita. There were approximately 2,000 miles of roadway in the Greater New Orleans area which were submerged in floodwaters for up to 5 weeks. After the hurricanes, there was great concern in the Louisiana Department of Transportation and Development (LADOTD) about the pavement structures in the flooded area due to the sustained flooding, as well as the pavement damage from the heavy debris trucking traffic. In this study, the pavement performance system (PMS) data for District 02 (most seriously influenced by Hurricanes) collected before and after the Hurricanes were analyzed to assess the pavement performance damage due to the sustained flooding or/and the heavy debris trucking traffic. The PMS data illustrated increased damage to highways as a result of heavy trucking or vehicle loading required to transport the vast amounts of debris following the Hurricanes. In addition, the data established an escalation in deterioration occurring as subgrade components were not initially designed to sustain such vehicle loads and may have been further weakened as roadways were submerged in water for extended periods of time.

INTRODCUTION

In August of 2005, New Orleans and southeastern Louisiana was devastated by Hurricanes Katrina. Nearly 4 weeks later, Hurricane Rita further damaging Louisiana's infrastructure and bringing destruction to the New Orleans area once again. There were approximately 2,000 miles of roadway in the Greater New Orleans area which were submerged in floodwaters for up to 5 weeks (Zhang et al., 2008). Figure 1 presents the map of flooded area developed by the Louisiana Department of Transportation and Development (LADOTD) based on information provided by the

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Federal Emergency Management Agency (FEMA), gathered on August 30 and September 2, 2005 (LADOTD, 2007). These two Hurricanes also left huge amount of debris. To transport the vast amounts of debris following the storm, heavy trucking or vehicle loading were required to move on pavements in these areas. Figure 2 presents the map of debris sites approved by the Federal Highway Administration (FHWA) and FEMA (LADOTD, 2007) in District 02 (most seriously influenced by Hurricanes). These debris sites distributed both on flooded and non-flooded areas. After the hurricanes, there were great concerns in the LADOTD about the pavement structures in the flooded area due to the sustained flooding, as well as the pavement damage from the heavy debris trucking traffic.

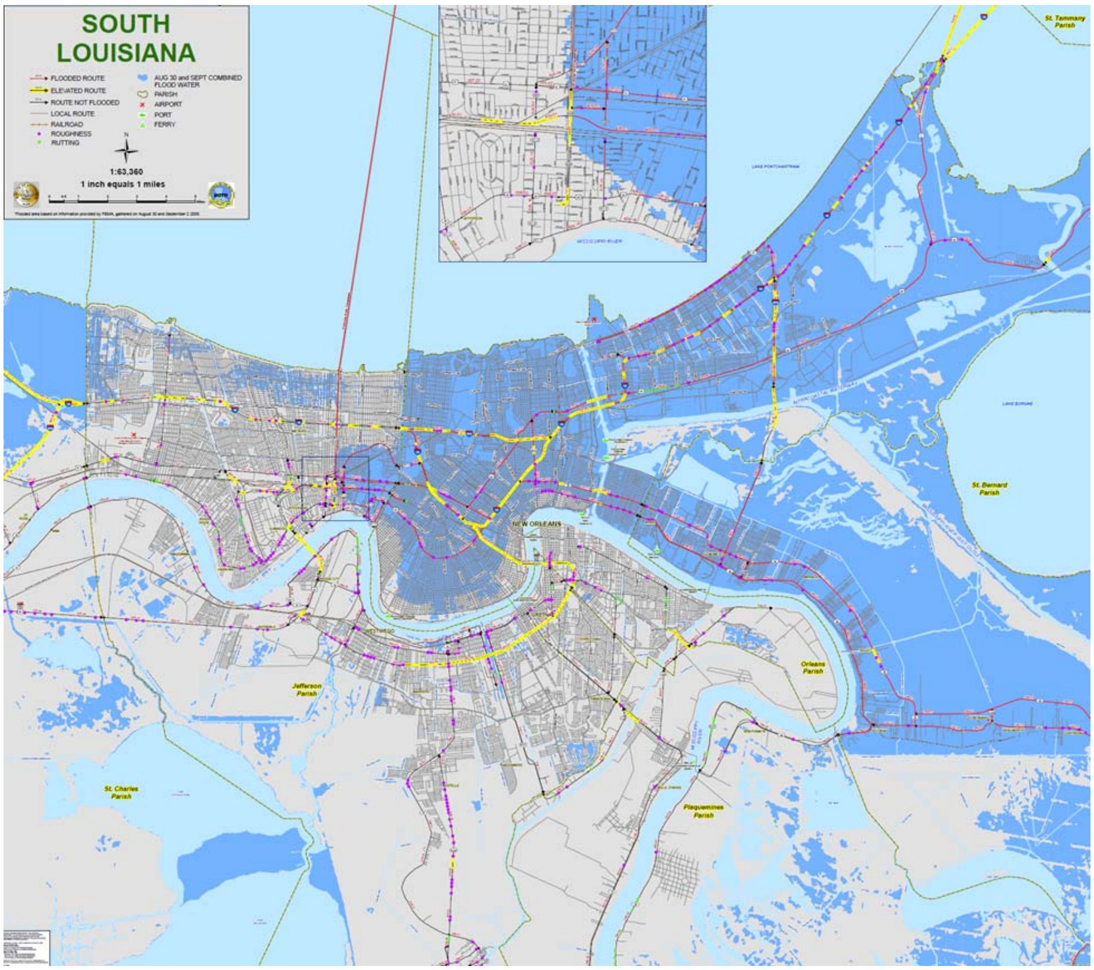

FIG. 1. Flooded Area Based On Information Provided By FEMA, Gathered On August 30 and September 2, 2005 (LADOTD, 2007).

In response to the concern about the pavement structures in the flooded area due to the sustained flooding, the Louisiana Transportation Research Center (LTRC) conducted falling weight deflectometer (FWD) and Dynaflect tests in November 2005 to assess the flooding impact to pavement structures in the area. LTRC's

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preliminary field test results showed that, at several test locations, very low modulus values were found for the 150 mm (6 in.) cement treated base course (modulus < 200 MPa), as was also the case for the 230 mm (9 in.) asphalt concrete layer (modulus < 1,000 MPa) and 200 mm (8 in.) concrete slab (modulus < 4,000 MPa) (Zhang et al., 2008). With these preliminary findings as support, the LADOTD contracted with a consultant to conduct a full scale pavement testing survey for the federally funded urban highway system in the flooded areas of New Orleans. The tests conducted by consultant included FWD, ground penetrating radar (GPR), and coring with dynamic cone penetrometer (DCP) at selected locations to verify pavement thickness or damage. The results of this field testing showed that, from the statistical network wide point of view, the flood waters did weaken asphalt pavement structures by reducing the stiffness of both the asphaltic layer and subgrade in the New Orleans submerged area. The flooding impact on PCC structures was limited when compared to asphalt pavement. And no conclusion could be drawn with respect to flooding damage on composite pavement due to the variety of pavement structures, composition, and materials in that group (Zhang et al., 2008).

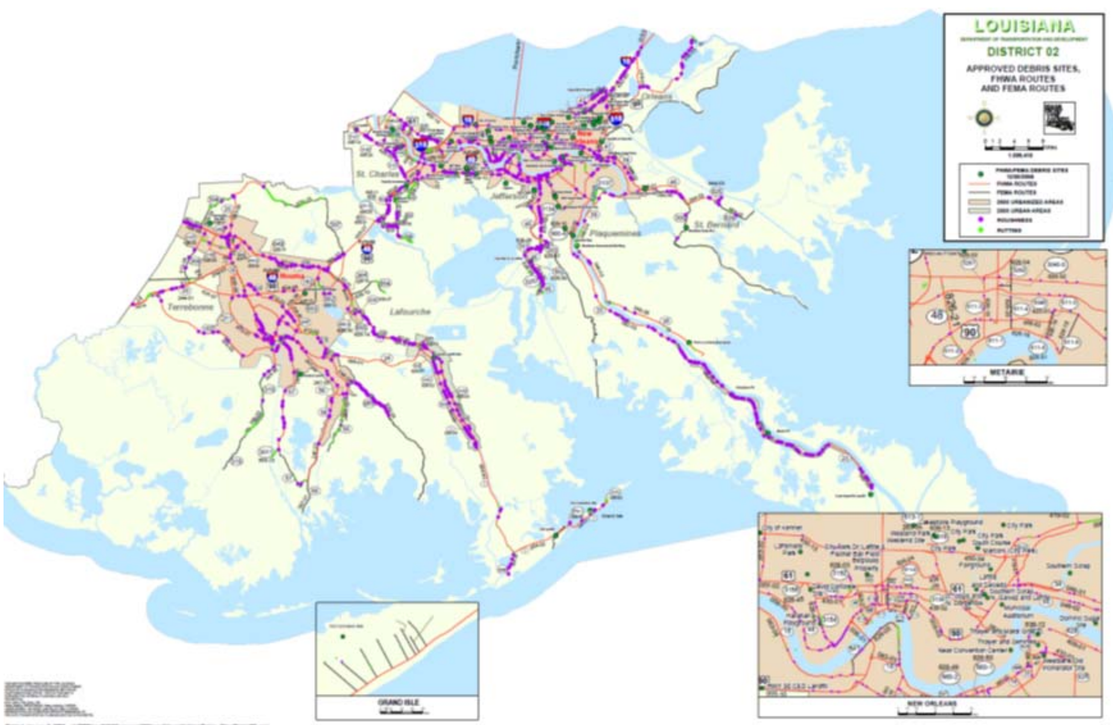

FIG. 2. Approved Debris Sites, FHWA Routes and FEMA Routes (LADOTD, 2007).

In this study, the pavement performance system (PMS) data for District 02 collected before and after the Hurricanes were analyzed to assess the pavement performance damage due to the sustained flooding or/and the heavy debris trucking traffic.

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ANAYSIS OF PAVEMENT PEFROMANCE

Louisiana's PMS has collected and preserved a recorded history of pavement surface condition data since 1995. In July 2005, a biennial data collection cycle was completed. After Hurricanes Katrina and Rita in August and September of 2005, a new data cycle began in August 2006. District 02 was recollected in a special contract from November 2007 through February 2008. Thus, a comparison of pre-storm pavement condition with one and two years post-storm condition can be made (LADOTD, 2008). These PMS data were collected using Automatic Road Analyzer (ARAN). The collected PMS data included international roughness index (IRI), longitudinal cracking, transverse cracking, alligator cracking, rutting for asphalt-surfaced roads, and faulting for concrete-surfaced road, etc. More details in PMS data collection can be referred to LADOTD PMS Manual (LADOTD, 2010).

In this study, IRI and rutting were selected to assess the pavement performance deterioration in District 02 before and after Hurricanes Katrina and Rita. Following criteria were used to query highly deteriorated pavement sections from PMS database for each same tenth of a mile section: 1) for IRI approach, the slope of deterioration from 2005 to 2007 was 10 IRI (in./mile) greater than the slope of deterioration from 2003 to 2005; and 2) for rutting approach, the maximum rut depth in 2007 was at least twice as that in 2005. Any sections that did not have IRI in 2003, 2005 or 2007 by tenth of a mile were not considered. For a section that had a negative slope for IRI from 2003 to 2005 (i.e. had a treatment on that pavement section), the difference between 2005 and 2007 was calculated by using the difference in slope greater than 10 on deteriorated section. The PMS video of queried sections were reviewed and any sections that contained excess spikes due to bridges, railroad tracks, turning sharply or stopping at a light were removed.

DISCUSSION OF RESULTS

Figures 3 to 5 were examples of PMS photos for asphalt, composite, and concrete pavements before and after Hurricanes at the same location, respectively. Figure 3 presents the PMS photos for an asphalt pavement section on LA 316 in Lafourche Parish. This section was not in the flooded zone but there was a debris dump site nearby. As show in Figure 3a), the pavement was in a good shape before Hurricanes. After Hurricanes, alligator cracking and patches were found in this section as show in Figures 3b) and 3c).

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a) Picture on 05/16/2005 b) Picture on 11/07/2006 c) Pictures on 11/14/2007

FIG. 3. PMS Pictures of Asphalt Pavement on LA 316 in Lafourche Parish.

Figure 4 presents the PMS photos for a composite pavement section on LA 49 in Jefferson Parish. This section was also not in the flooded zone but it was a heavy debris hauling route. As show in Figure 4a), the pavement had low severity level longitudinal cracking before Hurricanes. After Hurricanes, medium and high longitudinal crackings were found in this section in 2006 and 2007, respectively, as show in Figures 4b) and 4c).

Figure 5 presents the PMS photos for a concrete pavement section on I-10 in New Orleans Parish. This section was in the flooded zone and was underwater for a prolonged period. The distress at the transverse joint of concrete pavement was worse after Hurricanes than before.

a) Picture on 05/27/2005 b) Picture on 12/13/2006 c) Picture on 11/29/2007

FIG. 4. PMS Pictures of Composite Pavement on LA 49 in Jefferson Parish.

a) Picture on 05/24/2005 b) Picture on 10/25/2006 c) Picture on 12/14/2007

FIG. 5. PMS Pictures of Concrete Pavement on I-10 in New Orleans Parish.

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Table 1 presents the queried highly deteriorated pavements in district 02 based on IRI. A total 172 control sections in District 02 were queried with highly deteriorated pavement subsections based on IRI, including 51 sections in flooded zone and 121sections in non-flooded zone. Among these total 1025.8 miles pavements, there were 100.6 miles length (about 9.8%) highly deteriorated pavements based on IRI, including 29.2 miles in flooded zone and 71.5 miles in non-flooded zone. It was interesting that the highly deteriorated pavement length rate in flooded zone (7.9%) was slightly lower than that in non-flooded zone (10.9%). The average IRI values in 2005 and 2007 were shown in Table 1 and Figure 6. For asphalt and composite pavements, the average IRI values and IRI increments in flooded zone were slightly higher than those in non-flooded zone. For concrete pavements, the average IRI values and IRI increments in flooded zone were slightly lower than those in non-flooded zone. Over all, the average IRI values and IRI increments in flooded zone were slightly higher than those in non-flooded zone.

Table 1. Highly Deteriorated Pavements in District 02 Based on IRI

Flood Zone	Pavement Type	Control Section Numbers	Total Length (Mile)	Highly Deteriorated Length (Mile)	Highly Deteriorated Length rate (%)	Ave IRI 2005 (In./Mi.)	Ave IRI 2007 (In./Mi.)	ΔIRI (In./Mi.)
Flood Zone	Asphalt Pavement	19	91.2	5.8	6.3	134.2	181.8	47.7
	Composite Pavement	21	171.0	13.4	7.8	143.0	185.9	42.9
	Concrete Pavement	11	107.3	10.0	9.3	164.2	203.5	39.4
	Over All	51	369.4	29.2	7.9	147.1	190.4	43.3
Non-Flood Zone	Asphalt Pavement	62	294.0	34.5	11.7	127.8	169.9	42.1
	Composite Pavement	46	301.1	30.6	10.2	120.0	153.1	33.1
	Concrete Pavement	13	61.3	6.4	10.4	189.2	232.5	43.3
	Over All	121	656.4	71.5	10.9	145.6	185.1	39.5
Over All		172	1025.8	100.6	9.8	146.4	187.8	41.4

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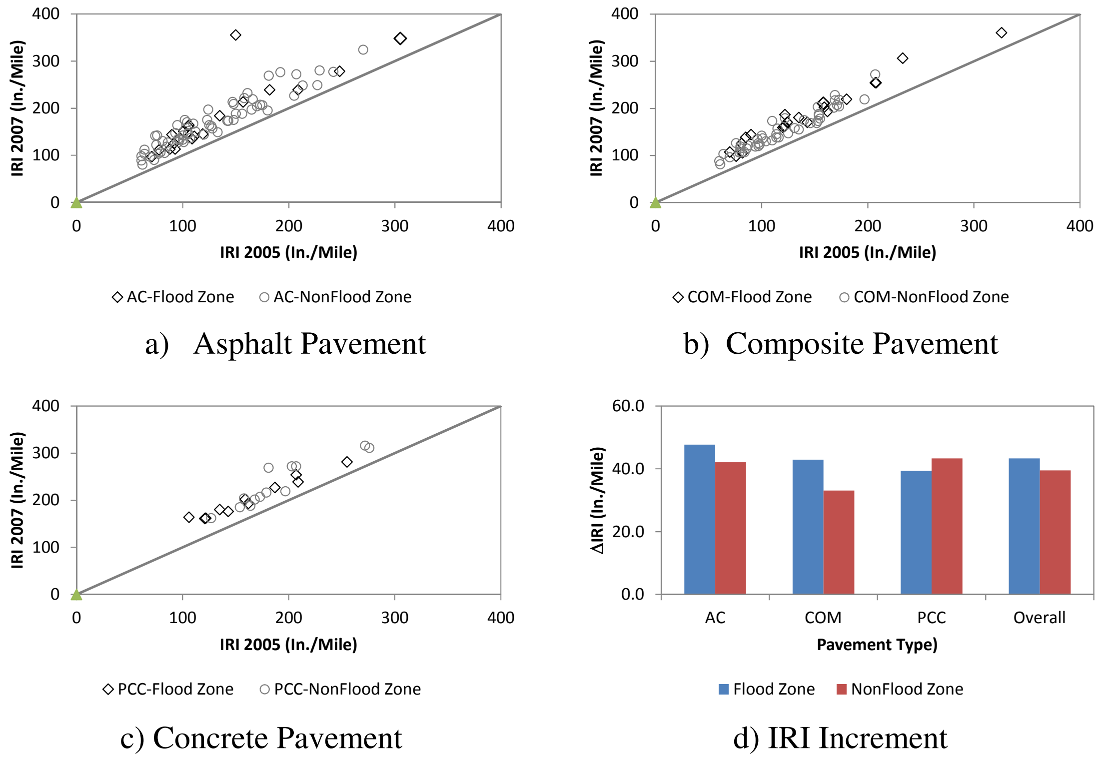

FIG. 6. Comparison of IRI in 2005 and 2007 for Highly Deteriorated Pavement.

Table 2 presents the queried highly deteriorated pavements in District 02 based on rutting. A total 90 control sections in District 02 were queried with highly deteriorated pavement sub-sections based on rutting, including 24 sections in flooded zone and 66 sections in non-flooded zone. Among these total 582.8 miles pavements, there were 34.5 miles (about 5.9 %) highly deteriorated pavements based on rutting, including 7.3 miles in flooded zone and 27.3 miles in non-flooded zone. It was interesting that the highly deteriorated pavement length rate in flooded zone (4.1%) was slightly lower than that in non-flooded zone (6.7%). The maximum rut depths within tenth of a mile subsection in 2005 and 2007 were shown in Table 2 and Figure 7. For asphalt pavements, the average maximum rutting depth for tenth of a mile subsection and increments in flooded zone were slightly lower than those in non-flooded zone; while, for composite pavements, the average maximum rutting depth for tenth of a mile subsection values and increments in flooded zone were slightly higher than those in non-flooded zone.

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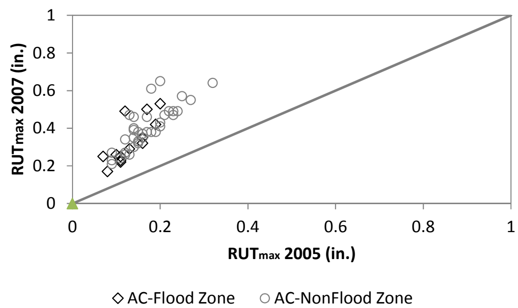
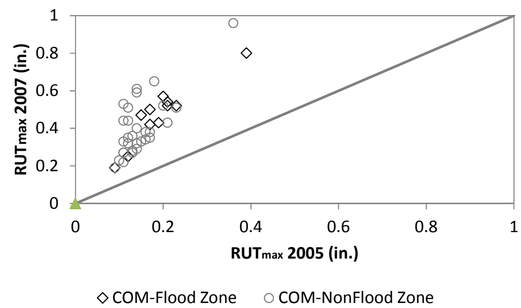
Table 2. Highly Deteriorated Pavements in District 02 Based on Rutting

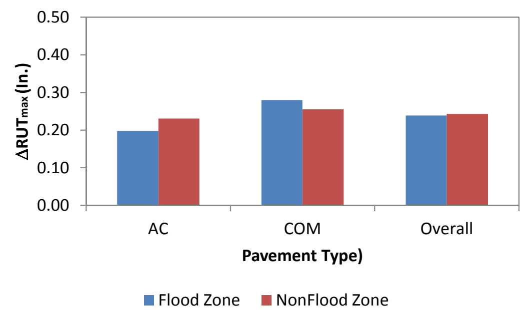
Flood Zone	Pavement Type	Control Section Numbers	Total Length (Mile)	Highly Deteriorated Length (Mile)	Highly Deteriorated Length Rate (%)	Ave Rut_{max} 2005 (in.)	Ave Rut_{max} 2007 (in.)	Δ(Ave Rut_{max}) (in.)
Flood Zone	Asphalt Pavement	13	65.7	4.0	6.1	0.13	0.33	0.20
	Composite Pavement	11	110.1	3.3	3.0	0.19	0.47	0.28
	Over All	24	175.8	7.3	4.1	0.16	0.40	0.24
Non-Flood Zone	Asphalt Pavement	36	189.7	19.5	0.2	0.17	0.40	0.23
	Composite Pavement	30	217.3	7.8	3.6	0.15	0.40	0.26
	Over All	66	407.0	27.3	6.7	0.16	0.40	0.24
Over All		90	582.8	34.5	5.9	0.16	0.40	0.24



a) Asphalt Pavement



b) Composite Pavement



c) Rut Depth Increment

Figure 7. Comparison of Rut Depth in 2005 and 2007 for Highly Deteriorated Pavement.

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CONCLUSIONS

In this study, the PMS data for District 02 collected before and after the Hurricanes were analyzed to assess the pavement performance damage due to the sustained flooding or/and the heavy debris trucking traffic.

For asphalt and composite pavements, the average IRI values and IRI increments in flooded zone were slightly higher than those in non-flooded zone. For concrete pavements, the average IRI values and IRI increments in flooded zone were slightly lower than those in non-flooded zone. Overall all, the average IRI values and IRI increments in flooded zone were slightly higher than those in non-flooded zone.

For asphalt pavements, the average maximum rutting depth for tenth of a mile subsection and increments in flooded zone were slightly lower than those in non-flooded zone; while, for composite pavements, the average maximum rutting depth for tenth of a mile subsection values and increments in flooded zone were slightly higher than those in non-flooded zone.

The PMS data illustrated increased damage to highways as a result of heavy trucking or vehicle loading required to transport the vast amounts of debris following the Hurricanes. In addition, the data established an escalation in deterioration occurring as subgrade components were not initially designed to sustain such vehicle loads and may have been further weakened as roadways were submerged in water for extended periods of time.

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DISCLAIMER

The information presented in this paper only reflects the views of the authors. No official endorsement should be associated with the information provided.

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