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Expedient site construction provided housing for Mississippi residents displaced by Katrina

Geosynthetic materials helped in offering a solution for the construction of temporary roads and group housing sites atop wet and soft soil conditions.

By Lloyd W. Young Jr. and Robert E. Jordan

Photo by Mark Wolfe/FEMA



The FEMA D'Iberville (Miss.) Middle School Emergency Group Site (EGS) was used for temporary housing of residents displaced by Hurricane Katrina.

Introduction

The objective of this article is to describe the use of geosynthetics during the preparation of temporary group housing sites in southern Mississippi after the destruction of Hurricane Katrina.

There was an estimated need for emergency housing for more than 100,000 people after the storm, requiring the rapid installation of more than 30,000 travel trailers and

mobile homes. Although many temporary housing units were installed adjacent to the damaged homes, there was an estimated need for up to 5,000 units at “group sites” in the three southernmost counties of Mississippi.

Since it was so important that these sites be developed in the least amount of time, pre-construction investigations and designs were simplified. Due to the shortage of equipment and materials, conventional designs that called for up

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Photo 1 | Robert Jordan is shown here evaluating the soil strength on a soft, wet site using the “sink” criteria.

Photos 2 & 3 | Common post-Katrina sites: Demolished housing and tangled debris.

This article describes how the method was developed, how it was successfully field-tested, and then employed by construction personnel to accurately assess actual conditions to significantly reduce the time and cost to develop temporary housing sites.

Katrina

When Hurricane Katrina struck the Gulf Coast of the United States in late August 2005, the damage was indescribably devastating and widespread. Reports from Alabama on the east through Mississippi and Louisiana to central Texas on the west described an incredible level of destruction of housing, commercial facilities, utilities, and infrastructure networks that was beyond belief.

The storm’s destruction within several miles of the Gulf shoreline in many cases left almost nothing intact. It demolished houses, schools, and other buildings, often leaving little more than a cement slab or a tangled pile of debris (**Photos 2 and 3**).

During the initial rescue and recovery operations, it was immediately evident to the leaders of the state of Mississippi and the federal government that emergency temporary housing would be a top priority as more than 100,000 families were displaced by the storm. The Federal Emergency Management Agency (FEMA) and the Mississippi Emergency Management Agency (MEMA) had the

to 2 ft. of crushed rock to develop a stable site work area could not be used.

Photo 1 shows Bechtel’s Robert Jordan evaluating the soil strength and the specific stabilization requirements on a soft, wet site using the “sink” criteria. The “sink” criteria was exactly as the name implies, which was using how far we would sink into the ground based on the soil shear strength, the degree of disturbance during utility construction and the soil moisture content to determine stabilization requirements.

The solution was an application of up to 4 layers of geosynthetics and aggregates, with just one layer applied to the stronger sites and perhaps all 4 layers needed for the softer sites. The process was such that if greater stability and less rutting were required, then another stronger layer was added without disturbing what had already been placed.

Temporary housing

primary responsibilities to coordinate the installation of these shelters.

Based on their experience and initial surveys, it was determined that many families could be helped with travel trailers or mobile homes placed in their driveways or on the lawns of their homes. This was possible where the damage was not severe and utilities such as water, sewer, and electricity were still operating or could be repaired quickly. It was also determined that existing trailer parks could be rehabilitated (the trailers that had been there were often destroyed or just gone). Placing emergency housing units at these locations started immediately, often simultaneously with utility repair and the removal of debris off roads and residential areas.

For families from damaged rental units, or in cases where their homes were destroyed, the installation of housing units at multiple locations was not possible because of the extensive destruction to the infrastructure and lack of access. In these cases, FEMA/MEMA planned to cluster travel trailers and mobile homes in group sites. For the quickest deployment, travel trailers were placed in FEMA-designated Emergency Group Sites (EGSs) that were located on paved parking lots with aboveground utilities. The time from the start of design to occupancy was often less than 7 days for the EGSs. For emergency group sites required in areas without parking lots, or for larger group sites for longer occupancy (called Greenfield sites), the team faced all the typical site-preparation issues that any construction project would face.

Site preparation planning

Due to the flooding, plus the naturally high groundwater table and soft soil conditions in coastal Mississippi, preparation of large group sites using conventional design methods would call for excavation of topsoil and soft soils, possible dewatering, and use of large quantities of borrow material for backfilling.

But with the disaster conditions, there were shortages of subcontractors with equipment and few sources of aggregate or suitable borrow material. In addition, with the quantities required in a typical

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site preparation, the time for construction would be greatly lengthened—a prospect certainly not needed in this emergency situation.

None of these potential delays were acceptable, since our charge was to move residents into the temporary housing as quickly as possible. Clearly, unconventional methods were needed to reduce both time and costs, while providing adequate ground/surface support for construction and then for use by residents of the group sites.

We had initially found that using layout templates and standard details could reduce the time required to prepare the drawings for construction of a group site to about a week. Following that idea, we decided to adopt a site-based approach to the prep work and then transfer the responsibility for many decisions to the field construction teams.

To implement this effort, we needed to develop the right tools for real-time decision-making, and then test and refine the tools for assurances that they would perform well. Since our goals were to reduce both the time and costs of construction, we found that the use of geosynthetic material was instrumental as part of site development to minimize the materials required and to provide flexibility to the construction teams.

Guiding principles

Several key principles were quickly adopted to make expedient site preparation a reality. The limitations on available materials and time were obvious at the forefront. But since these installations were temporary and the areas would likely need restoration after residents moved back home, opportunities were present for innovative site preparation. Further, the access roads were not paved. This allowed more flexibility with subgrade performance, and rut development in the aggregate surface, than on normal commercial or residential construction.

The guiding principles were:

- Use the existing topography to provide site drainage and minimize regrading. Adapt the layout of housing units and roads to take advantage of existing ground slopes. Only grade to fill in low spots or ditch to prevent ponding.
- Do not strip the topsoil from the site. The topsoil internal structure takes years to develop, and from an environmental perspective, it is desirable to minimize disturbance and leave the soil in place. Since the topsoil would require replacement after site decommissioning, just leaving it in place and “building over the top” is a good idea.
- Do not undercut soft or wet soils. Try to minimize excavation and backfill quantities, reduce the time of construction, and eliminate working in wet conditions.
- Use geosynthetics (geotextiles and geogrids) to provide necessary separation, reinforcement, and drainage for road access, parking, and trailer pads. Good access must be provided and must be relatively maintenance-free for construction traffic, site residents, service equipment, and emergency vehicles including fire, police, and rescue/ambulance.

As expected, these “principles” needed not only practical and clear descriptions on the drawings, but some testing and refinement by the experienced construction supervisors and subcontractors to make sure they were well suited to the existing conditions.

Templates and tools for road design and use of geosynthetics

Due to the temporary nature of the group sites, the plan included all aggregate-surfaced roads with only limited paving at the entrances if needed to comply with local requirements.

Temporary housing



Photo 4

The road design template was developed following the guidelines in TM 5-822-12, *Design of Unsurfaced Roads and Airfields*, HQ Department of the Army, using: Road Class “E” (210 to 2100 vehicles per day); Design Index = 1; Design CBR = 4 - 8. This resulted in a 4-in.-thick layer of Mississippi DOT (MDOT) Size No. 610 crushed limestone aggregate, which was increased to 6-in.-thick at entrances, areas of traffic channelization, and heavily used turns. Since aggregate was in short supply due to the reconstruction activities, the CBR was set optimistically to be able to maximize the number of sites that were constructed with available funding.

To minimize the loss of aggregate into the subgrade soils and to provide some degree of reinforcement, MDOT Type 5 nonwoven geotextile was specified for placement under the aggregate. **Photos 4 and 5** show the geotextile being unrolled for a group site roadway over the grass and topsoil, with the aggregate placed and compacted.

As group sites were systematically identified and evaluated, and approvals were secured from local, state, and federal agencies, we were learning more about the variability in the site and soil conditions. As expected, we were able to use the “road surface template” as a base-case condition that we called Type 2 and then added

a Type 1 template for non-load-bearing areas (grass covered), plus Type 3 and Type 4 templates for the subgrade improvement needed for the soft and wet site conditions.

For the Type 3 conditions, a high-strength woven geotextile was used in place of the MDOT Type 5 nonwoven to allow better drainage of any

water trapped under the geotextile. In addition, the thickness of the aggregate was increased up to 8 in. for roads and 4 in. for parking areas and trailer pads.

For Type 4 conditions, an initial 8-in.-thick layer of railroad ballast was used on the high-strength geotextile to provide greater stiffness and drainage. An intermediate geogrid reinforcing layer was placed on the ballast to facilitate bridging over soft soil conditions and then sandwiched with the needed thickness of MDOT 610 limestone to create the road surface.

These four types of site preparation criteria were placed on a single small drawing that also included all the site drainage and other preparation criteria. For example, any trees that needed to be cut were trimmed flush with the ground surface to eliminate disposal of the stumps and to avoid creating water-filled holes.

Field evaluation of conditions: The “sink factor”

The use of these design templates provided the flexibility for dealing with vari-



Photos 4 & 5 | Part of the solution was an application of up to 4 layers of geotextiles and aggregate, with just one layer applied to the stronger sites and perhaps all 4 layers needed for the softer sites.

able soil conditions. Although site evaluations confirmed that Type 2 would be the most commonly encountered, it was possible that rainy weather, local areas of poor soil, or construction equipment disturbances during utility installations would either worsen the conditions or we would just find the bad areas.

To prepare accurate work plans and estimates of cost and schedule, we needed to find a way to quickly assess the ground conditions to determine those areas that needed increased amounts of materials and to limit those areas as much as possible to control cost and schedule.

Since the site construction team was the most familiar with the conditions, we developed a rating scale for them to use based on how far they would sink into the ground. This rating scale was based on the CBR values for the subgrade soils, but employed more practically. The Type 2 conditions had “a person sink about ½-inch” into the ground while the Type

4 conditions had “a person sink instantly to the top of boots.”

Due to the dual needs to provide housing quickly and to minimize costs, an evaluation tool that involved a person sinking into the wet soil was readily accepted without hesitation.

With the technical assistance of a local geosynthetic supplier, field tests were run to validate both the design template and the “sink factor” rating scale and to introduce local subcontractors to the use of geotextiles and geogrids.

The materials for this test were literally mobilized overnight after only a few calls to suppliers. The demonstration was performed in the rain (the work rarely stopped) and the use of geosynthetics and aggregate that was not moisture sensitive kept the work moving rain or shine.

Results

With the leadership of the site construction team, the support of the

geosynthetics industry, and the cooperation of the local subcontractors, the construction of group housing sites proceeded faster, and housing was provided sooner, for the residents of southern Mississippi.

All group sites were inspected periodically to make sure the roads and drainage systems were working as “field engineered.” Other than filling some low spots, making the roads wider on the corners, and adding extra places for the residents to park, the expedient construction was a success.

During the initial recovery period of about 8 months, more than 31,000 housing units were installed in Mississippi, many in group sites that started with soft and wet soil conditions. The site soils were stabilized and the work was accomplished faster and at lower cost using geosynthetics and the construction team’s “sink factor.” 