

# Protocol to Construct Post Disaster Homes in Short Time Span in the USA

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## Abstract

Recent global climate change resulted in unfavourable impacts on the earth's atmosphere increasing number of natural disasters around the world. Population growth and expansion of human habitat has escalated consequences of disasters and emphasized importance of response plans. Significant portion of response plans are to address housing provision as well as reconstruction. Response time is one of the major factors in response plan, since the stress caused by the disaster on victims increases drastically with the increase in response time. Impacts of longer response time would often lead to community displacements and causes shortage of resources in the area, ultimately affecting the economy and social equity of the region. The overwhelming consequences of response plans in natural disasters have forced emergency planners to review existing emergency strategies, exploring possibility of reducing response time.

A strategic framework is proposed in this study to construct 200 quality temporary shelters in USA within 30 days. The main objective of the research is to demonstrate feasibility of the planning process and steps required to achieve indicated goal considering supply chain and local constraints. Simulation software EZStrobe is applied to replicate various scenarios with different parameters and suggest a concrete plan of activities and their sequences. Implementation of this protocol would help emergency planners to reduce response time substantially helping victims to recover quickly from disaster consequences. This will shift efforts to reconstruction of the affected region eventually contributing to economy of the target community.

**Keywords:** Emergency Shelter, Reconstruction after Disaster, Post Disaster Housing.

## **Introduction**

Global climate change has affected earth's atmosphere by altering the temperature of land and water surfaces (NOAA 2009). This has augmented number and probability of disaster occurrences. This situation is not quite different in the United States (Weiss et al. 2009). Disasters are the extreme events that often leave behind devastation in different parts of the country. Destruction rates and expenses are on a rise compared to past disasters. For example, hurricane Katrina, California wildfires and Midwest floods in 2008 have surpassed historical records. The common element has been damage done to homes. Thousands of homes have been severely damaged or destroyed during these disasters and thousands of citizens are left homeless. The enormous number of homeless victims has raised many challenges for emergency agencies and questions against the robustness of existing response plans.

Emergency shelters are provided to victims till the danger of the disaster passes by. While temporary shelters are built to house them when they are repairing or reconstructing their homes. Homes being the basic need of human being, it is necessary for the emergency planners to provide good quality homes. Planners should also arrange for facilities like school, grocery stores, church etc (Weiss 2006). This would reduce the post-disaster stress level of victims and help them to focus on redevelopment process. They can start their routine life leaving behind appalling memories of disaster. Victims usually stay in temporary shelters and interim homes upto eighteen months and sometimes more than that. This research aims to reduce this time period and thus their post-disaster distress.

## **Background**

Fulfilling requirements of victims and re-establishing damaged or destroyed facilities is the core of response or relief plan of different emergency agencies. At the time of distress, operations are facing limited capabilities and resources, individuals and communities are having post disaster difficulties. These difficulties range from repairing their damaged homes to getting a temporary shelter after disaster. Some of them, whose homes are destroyed during disasters, need options for permanent home during or after their stay in temporary shelters. One instance in housing assistance can be when individuals need shelter as they cannot cope with the size of damage and destruction. Besides affected community might not have clear plan about procedures of repairing and are trying to work in order to reduce the high stress post disaster time, bringing the living standards of people to pre disaster status.

Federal Emergency Management Agency (FEMA) provides travel trailers or other forms of temporary shelter to the disaster victims to stay in till they can return to their homes or find some new better place to stay. They sometimes have to stay in these trailers for 18 months. These FEMA travel trailers were criticized for their inferior quality which affected life of many. During the time of hurricane Katrina, to achieve rapid distribution of FEMA trailers, federal government distributed more than 98,000 FEMA trailers which later lead to unfavorable health conditions such as psychological maladjustment like severe chronic depression and stress disorder (FEMA 2006). These adverse health conditions were the consequences of the presence of the hazardous chemical formaldehyde in the construction materials used to produce FEMA travel trailers. Formaldehyde is identified

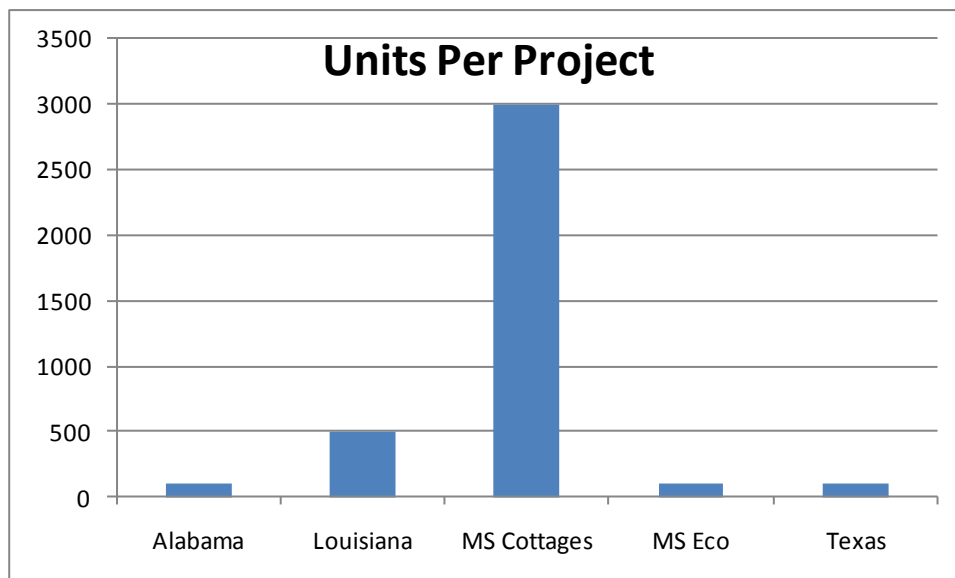
as a probable human carcinogen by the U.S Environmental Protection Agency which had been used in various products such as composite wood and plywood panels to construct trailers. This suggests the need of a secure, health promoting temporary housing for disaster victims.

After seeing the extent of the damage done due to the hurricane Katrina, it was important to satisfy the need for long term housing recovery. Also undesirable effects of FEMA trailers made them highly inappropriate for extended temporary housing needs. Thus to identify, design and construct alternate housing that can be used after disasters for long-term and more permanent use, FEMA was allotted \$400 million by the Congress in June 2006. FEMA in partnership with Department of Housing and Urban Development (HUD) introduced Alternate Housing Pilot Program (AHPP) to use these funds for both homeowners and renters in the Katrina affected states that are Alabama, Mississippi, Louisiana and Texas. Below is the table that shows the distribution of money among four states for five projects (Johnson 2009).

**Table 1** Allocation of AHPP funds to Four States (Adapted from: Johnson 2009)

State	Fund
Alabama	\$15,667,293
Louisiana	\$74,542,372
Mississippi	\$281,318,612
Texas	\$16,471,725

Also, around 3800 homes were to be constructed through five projects in the above listed states. It should be noted that the state of Mississippi received the highest amount of money through AHPP for implementing two projects, Mississippi Cottages and Eco-Cottages. Below is the graph that shows number of units to be constructed in five projects. Some of these projects are still under implementation.



**Figure 1** Housing Units per AHPP Project (Adapted from: <http://www.fema.gov>)

AHPP was introduced after the hurricane Katrina and delays occurred due to various reasons. Changes were made in the design and installation process of these units which

led to a time consuming phase of negotiations between the emergency agencies and manufacturers for changes in materials to be used, skillfulness of workers, and architecture of new units. Different housing units have different designs and they differ in color, architecture, and compliance to include accessibility of the unit to the disabled according to Uniform Federal Accessibility Standards (UFAS). This variety in housing units increased intricacy while manufacturing and distributing these units. This also led to delay in construction. FEMA and HUD initiated AHPP to determine disaster housing options that can be used to satisfy long-term and more permanent housing requirements. But Park Models and Cottages do not have required space so that they can serve as permanent homes. Moreover, local government and community leaders also showed resistance to AHPP units as they did not want to affect the economic and physical redevelopment process which they had already started (AAI 2009).

Thus experiences in AHPP clearly defined the necessity of a framework that would help emergency agencies to distribute emergency housing units timely which can also be used as permanent homes. There is a need to identify a unique house design which can be used by both providers and manufacturers. This would help to generalize and accelerate house installation at the site after disaster. Also local governments, community leaders and citizens get involved in restoration and redevelopment of infrastructure and facilities that make it difficult for them to participate in the disaster housing assistance process. Thus the current practice of making decisions about post-disaster housing has not solved the problem of emergency agencies of alleviating the suffering of the victims and providing them long-term housing with good quality. This research aims to perform a feasibility study of making a framework of a strategy that provides 200 houses within short period of time after disasters and help emergency agencies in assuaging the stress of victims and start their routine life soon after disaster.

## **Research Methods**

Research methodology can be divided into four tasks. First task involves performing literature review. This would help in studying current practices used in the USA for providing emergency assistance, relationship between the various agencies, and about housing alternatives available. This would also establish housing needs of victims after disaster. In second task, the framework of developing the post-disaster housing strategy is established. This framework contains four different phases of strategy development. In the third task, basic guidelines and tasks to carry out first two phases are determined. And in the fourth task, post-disaster tasks established in previous task are simulated to optimize the response.

### **Research Hypothesis:**

- It is feasible to construct two hundred manufactured homes in thirty days after disaster.

## Framework of Developing the Strategy

Presence of uncertainty during disaster events prevents clear identification of needs. Most of the response plans are multifaceted that include complex requirements of individuals and communities. Moreover, constraints are enforced on emergency managers when required resources and necessary infrastructure are not available. More deliberated and detailed response plans are required in order to reduce response time as effectiveness of the response reduces drastically with time. Housing response time is the most critical part, as delay in providing assistance leads to many consequences like community displacement and mental stress. The strategy is developed with the main aim of reducing housing response time to as low as possible, probably to thirty days. Such strategy would not only help emergency agencies and allow them to concentrate on other emergency operations, but also individuals and reduce their sufferings. There are four basic phases involved in the framework of developing such a strategy to increase preparedness of emergency agencies.

Those four phases are:

- Pre-Disaster Planning
- Emergency Entities and their Roles
- Optimizing Response/ Case Studies
- Implementation after Real Disaster

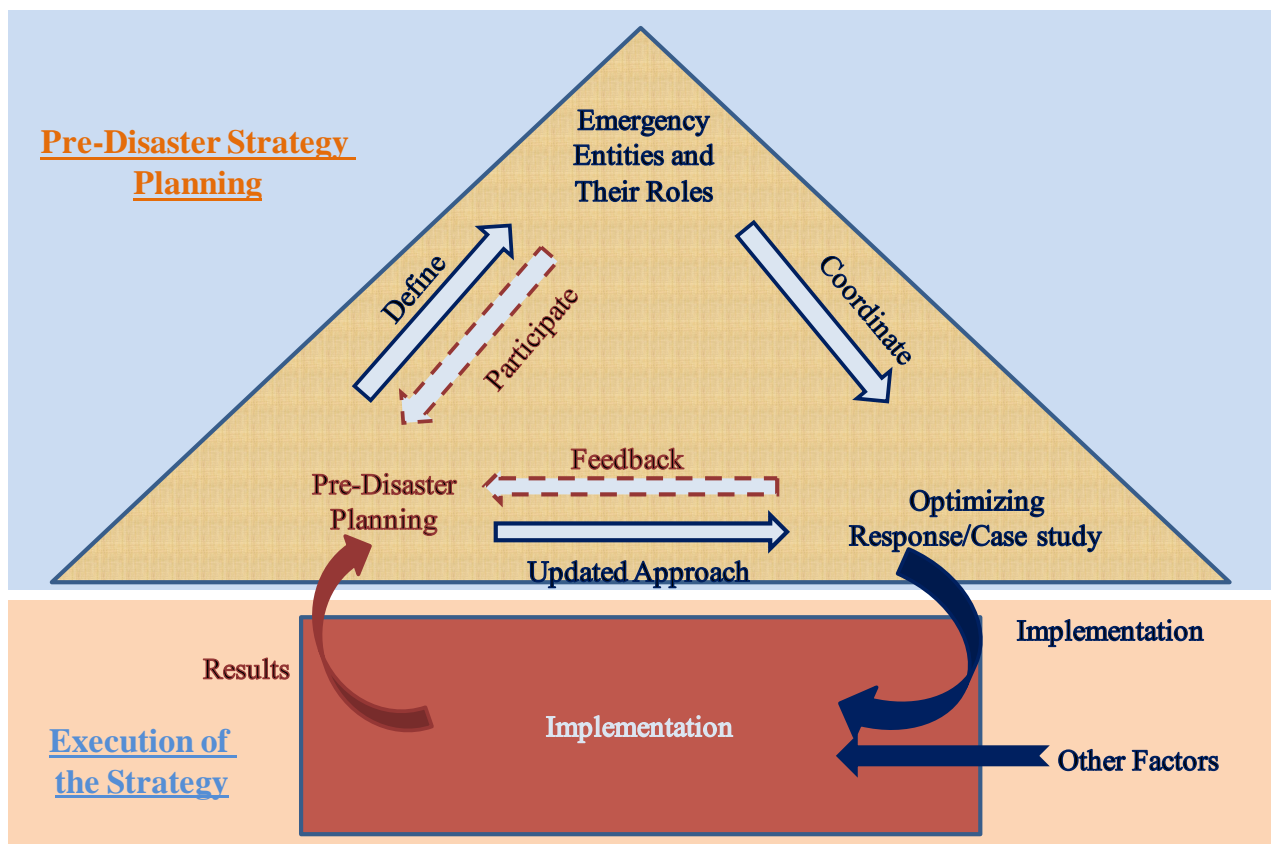


Figure 2 Framework of Developing the Strategy

The above four phases of the strategy development can be further classified as Pre-disaster (Pre-Disaster Strategy Planning) and post-disaster (Execution of the Strategy) phases. Pre-disaster phase of the framework, it includes Pre-disaster planning, selection of emergency entities and setting up their roles, and optimizing response. This phase will help emergency agencies to be better prepared for the disaster. The post-disaster step involves implementing the optimized strategy for providing homes to disaster victims in a short period. This phase will also involve implementing lesson learnt from previous cases.

Above figure 2 depicts the framework of developing a strategy to construct and provide 200 manufactured homes which involves four basic phases. The process of developing the strategy starts with Pre-disaster Planning phase. This phase of the strategy, decision makers are involved to estimate the scope of the work, list of possible activities to be performed before and after disaster occurrence. A brief information about the approach, planning, and execution of strategy are discussed here which will be explained in detail in the later section.

Pre-disaster planning phase defines the roles and responsibilities of different emergency entities and if possible then assigns those particular activities and tasks identified in this phase. Legal agreements such as contracts would be required between decision makers and participating entities (mainly private sector entities like manufacturers, contractors, material suppliers etc.). Once contracts are established to execute the strategy to respond to disasters, entities can participate in finalizing the scope of activities. They can also participate and assist decision makers to define logical sequence of activities to be performed to construct homes for victims. Thus decision makers and participating entities are involved in the Pre-disaster planning.

After defining the scope of work, studies can be done to optimize response time of each process. Techniques such as computer simulation model or implementing the strategy through pilot project or drills would help emergency planners to incorporate external factors while optimizing response time. This would help planners in determining the level of coordination required among the participating entities. This would also help in defining the level of accuracy needed in estimating resources and time required to perform assigned tasks by entities. Such study before implementing the strategy would facilitate the analysis of time and cost trade-offs, and verify the optimum combination to implement the strategy based on the studies performed. Emergency planners get feedback from such optimization studies which would help them to update the approach, activities and timeline of their execution.

After going through these three parts of developing the strategy, decision makers would have a clear and well defined scope of work and roles of various entities, logical sequence of possible activities and their time of execution. The strategy would really be tested once it is implemented in a real disaster scenario where real time results may vary depending on the assumptions and other external factors included while planning and optimizing the strategy. Such results can be the product of other factors like unexpected damage done to essential infrastructure, unavailability of funds, damage done to properties of involved entities and so on. Such unexpected results and consequences can be included in the Pre-disaster strategy planning phase for future disasters in order to improve the strategy and thus the response to disaster.

## Issues to be Considered in Planning

Apart from setting up of goals for activities involved to shape an effective strategy, there are some issues that need to be addressed. It would be better to resolve these issues in the planning stage to avoid their consequences during the execution period. These issues are:

- **Availability and sources of funding:**  
This strategy would require construction of two hundred homes after disaster. As a result of this strategy there would be a subdivision added to the city. These homes would serve the purpose of temporary housing, but they would be constructed for permanent use. And so the cost of construction would be higher than the cost of providing FEMA trailers or the cost of construction of mobile home parks for victims. Thus, the source of funding required for this strategy will be identified in the early stages of planning. However, the cost can be retrieved through mortgages or selling these homes to rental agencies.
- **Coordination and collaboration among the entities:**  
As discussed earlier, entities of different levels and background are involved in this strategy. As the entire project is very critical which requires successful completion in short time, i.e., 30 days, it is important to ensure coordination responses between them. It is likely that the entities may get less little or no time to get familiar with the disaster situation. Moreover, the strategy's main aim is to complete construction of homes in thirty days, their coordinated response would help the entire organization in contributing on time and finishing the project as per the schedule.

This issue can be overcome by scheduling weekly team meetings among agencies for clarifying roles and responsibilities. Also simulation of activities of various entities would help them practice the coordination required during post-disaster time. In the planning process the role of the local government would be very critical, as they will convey goals and scope of the strategy to all the entities and coordinate their ideas and proposed alternatives. In such a planning process output of one entity would be the input of another entity. The local government will manage the format the data which will be shared by various agencies and will increase the level of understanding and improved collaboration and planning.

- **Pre-positioned contracts:**  
Pre-positioned contracts would be established with contractors to involve them in the strategy execution. These contracts could be indefinite quantity (IQ), indefinite delivery (ID) contracts with the definite time period of around five years. There may be some changes to be made in the contracts based on the disaster experiences for improving post-disaster performances. So there has to be flexibility in the contracts to adjust its improved version based on the earlier experiences.
- **Logistics and Transportation:**  
During the planning phase the local government would decide and establish contracts with manufactured houses factories to provide houses during an

emergency. The local government and these factories together have to finalize the routes that would be used to transport homes to the site before disaster. They have to look for more than one alternate route in case the disaster affects any one of the routes. Also they have to decide the method of transportation. They can be transferred using truck trailers, rails or water in some cases. So they have to decide and choose the safest and quickest method of transportation. This would also help them in getting permission from different agencies for transportation. For example, if they finalize the transportation route to be a state or national route then they have to seek permissions from the highway department. Same with the other contractors would have to finalize the expected routes. They would use to mobilize the resources and supply materials. This planning logistics of homes, material and equipment and getting related permissions from particular agencies would definitely help in reducing response time.

- **Availability of infrastructure facilities and resources:**  
There is a high possibility that the local infrastructure would get damaged due to a disaster. It may take some time to restore or repair that infrastructure facility. So planners along with contractors have to finalize infrastructure facilities that would be required to activate and implement the strategy. They may not require the entire infrastructure at their full serviceability. So they have to decide the particular level of serviceability of each of the infrastructure facility. Moreover, the resources of the local government would get busy in providing emergency assistance and in restoring their own facilities, buildings and homes. In such cases, planners may not have enough resources for housing assistance. So planners have to plan for such scenarios and arrange for resources from neighbouring jurisdictions or state or federal governments. They have to sign MoU for this, during the planning phase.
- **Damage done to the contractors resources:**  
During the bidding procedures, local contractors and companies are given priorities over others in order to get their resources quickly on site and to help local businesses. But it may be possible that contractor's resources like equipment and/or labor may get damaged and become unavailable for the construction process. Planners have to consider such situations in the planning phase, where contractors would not be able to provide their resources and thus not be able to participate in strategy execution. Planners have to prepare the list of alternate contractors who can be contacted during emergency time. There are emergency contractors that could be used during such situations under FAR.
- **Supply chain of manufactured home factory:**  
In a normal scenario an order takes time before it gets processed where it has to get through different departments within the organization before the purchasing department orders the required material from suppliers. Then suppliers take their time in processing that order and supplying the ordered materials to the factory. This process takes about one to two weeks depending on the availability of materials at the supplier's end. And thus the production of houses takes about a week or two to start. This would delay the strategy implementation. To avoid such a situation during emergency times, factories have to make arrangements in their supply chain so that the production would start soon after the disaster and the houses would be transported a week after activating the strategy. Planners have to



closely review the arrangements made by the factories and choose factories that have made sufficient changes in their supply-chain to provide houses on time.

### **Research Objectives:**

- To perform a feasibility study of implementing a strategy, of constructing two hundred houses in short time (thirty days) as a rapid response to disaster.
- To provide good quality shelter (temporary and/or permanent) to the affected people, which can be executed by the emergency agencies after disasters in the USA and which would also reduce suffering of victims.

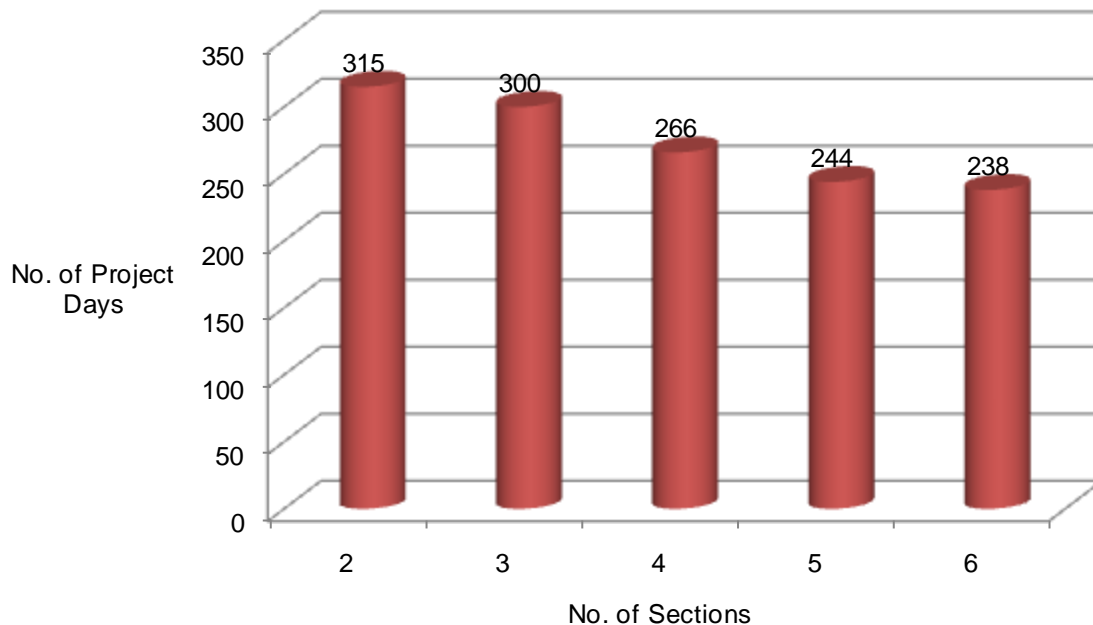
### **Research results**

The third phase of developing the strategy would optimize the objectives of response. These objectives are time, cost, and resources (labor and equipments). All these objectives are related to each other where increase or decrease in one would change others. For example, with the increase in number of labor and equipment would reduce the time and increase the cost of activities. This may also create problems in site management due to limited space. Thus optimization of response is required to avoid such consequences. This could be done by simulating the post-disaster activities using a computer model or organizing practice drills.

To optimize the resources required to construct two hundred homes in thirty days, a hypothetical disaster situation was created for Lafayette and West Lafayette city area. Certain pre-disaster tasks like site selection, selecting house design and manufacturers, selecting routes to transport home to site, designing site layout and estimating quantity of work, were carried out as a part of developing a combined strategy for both cities. Then a disaster scenario is simulated to verify if the construction of two hundred homes is possible within thirty days. EZStrobe simulation software is used to simulate the construction process.

A logical sequential flow of the post-disaster tasks was determined for the simulation process. Here, the site layout was divided into different sections from two to six to allow particular lag between two consecutive tasks. This would also permit simultaneous execution of different tasks. The logical sequence of tasks was followed for each section separately. After several simulation runs, it was found that it takes around 315 days to construct two hundred homes when site was divided into two sections and only one crew executed each task at a time. This number reduced to 238 days when site was divided into six sections. The results for different scenarios are shown in figure 3 below.

## No. of Project Days for One Crew

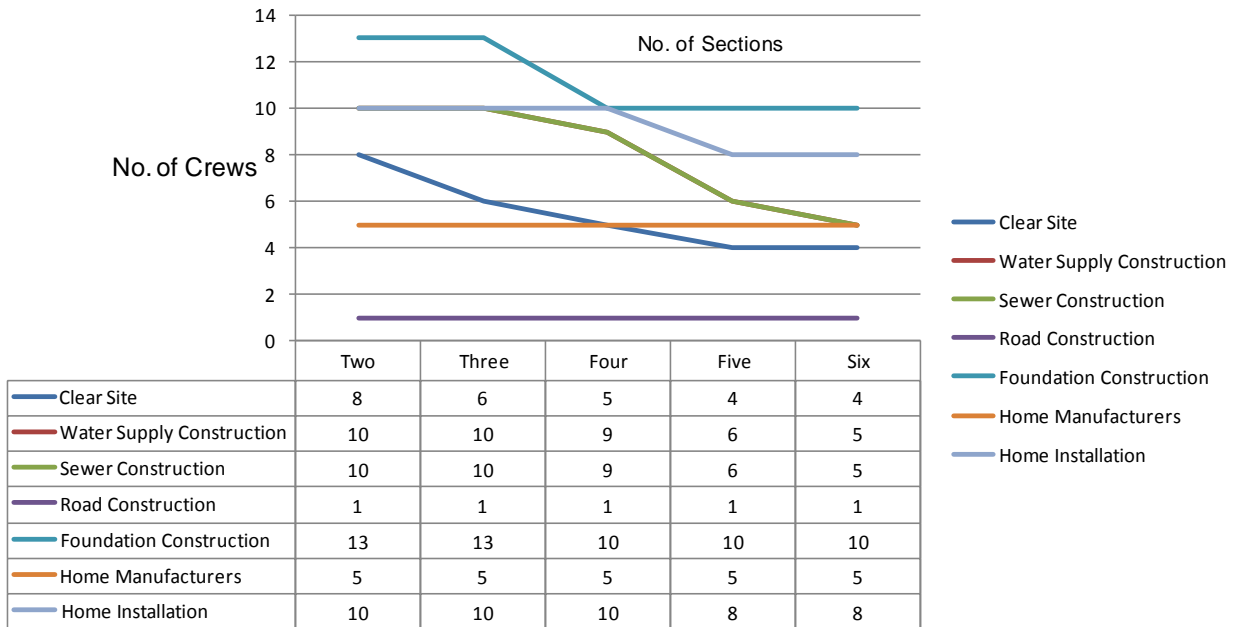


**Figure 3** Number of Project Days for Different Lead Time Scenarios

By increasing the number of crews for each process, the duration of the project can be reduced. The simulation model was used to determine the minimum number of resources required for each of the five cases (two to six site sections). Results obtained are shown in figure 4. Eight number of site clearing are needed to complete the project in thirty days that are two times more compared to four crews in case of five and six sections. The same way the number of required crews decreases significantly for water and sewer supply construction from ten in case of two sections to five in last case. As road construction process is not a critical process, its duration and time of occurrence do not affect the project much. So there is no need of getting more crews for this process to reduce its duration. For rest three activities, significant number of crews or entities is required for almost all the cases as they are critical processes. So if one process is delayed or slow in making progress, it does affect the total project duration. Thus by employing more crews, it would be possible to reduce the duration for all these processes.

The least number of crews were required in last case. About four site clearing crews, five crews for each of the water supply and sewer system, ten foundation crews, five factories and eight home installation crews are needed in this case to initiate and execute the project in thirty days. Dividing site in to six sections would allow most of the crews to work on different parts simultaneously as they get available from predecessor process. Thus optimization phase works as a guide that would help all the participating entities to visualize post-disaster events, to prepare steps depending on the number of site divisions made, to prepare guideline for transition from one phase to the other and to envision required level of coordination with others.

## Crew Comparison



**Figure 4** Resource Required for the Strategy

## Discussion and conclusions

This research proposes a basic framework to develop a strategy to construct post-disaster housing in short time period (thirty days) after disaster. It explains different processes that are followed to build up a strategy in four phases. It institutes guidelines and other requirements in the initial planning phase. It also establishes the roles and responsibilities of different entities along with their relationships and organization during emergency time. The framework proposes the requirement of such a strategy that would prepare agencies handle disaster in a better manner and reduce its impact to a certain extent by planning ahead of time. This would also save time in planning after disaster. Also though exercises and simulations the response processes can be made more robust to tackle any disaster scenario and prepare all participating agencies.

This research would mainly assist agencies that respond to disaster events and provide housing assistance to disaster victims. That would include agencies like local government, state government and federal government and its agencies such as federal emergency management agency (FEMA) and department of housing and urban development (HUD). By implementing this strategy during the emergency time would enable them to construct good quality homes in just thirty after disaster. This would reduce sufferings and stresses of victims due to disaster events. Also this strategy would serve as the foundation for future strategies.

**Key Lessons Learned:**

- Post-disaster housing plays important role in the redevelopment of communities after disaster
- Response time is the most critical part of housing assistance as its effectiveness decreases with increase in response time.
- If such a strategy would have been established prior to disasters, it will help emergency agencies and planners in providing housing assistance.
- Implementation of such strategy would offer better solutions for both temporary shelters as well as permanent homes after disaster.

## References

- Weiss, N.E. (2006) "Rebuilding Houses after Katrina: Lessons Learned and Unresolved Issues" Congressional Research Service.
- Johnson, N. (2009) "Alternative Housing Pilot Program" National Hurricane Conference.
- National Oceanic and Atmospheric Administration (2009) "2009 Global Temperatures Well Above Average; Slightly Above Average for U.S", (electronic article on the Internet).
- Abt Associates Inc. (2009) "Developing A More Viable Disaster Housing Unit: A Case Study of the Mississippi Alternative Housing Program".
- Weiss, D.J and Goad, E. (2009) "Global warming triggers more disasters", Center for American Progress, (electronic article on the Internet).
- National Low Income Housing Coalition (2007), "Timeline of the Federal Government's Temporary Housing Response to Hurricane Katrina", (electronic article on the Internet)
- Federal Emergency Management Agency (2006) "Formaldehyde Statistics", (electronic article on the Internet)
- Patel, S. M. and Nadepajouh, N. and Hastak, M. (2009) 'Post Disaster Housing – A U.S. Perspective"
- Verderber, S. (2008) "Emergency housing in the aftermath of Hurricane Katrina: an assessment of the FEMA travel trailer Program", Journal of Housing and the Built Environment, Springer.
- Federal Emergency Management Agency (2009) "National Disaster Housing Strategy", Department of Homeland Security.