BY DESIGN: THE DISASTER RESISTANT AND QUALITY-OF-LIFE COMMUNITY

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ABSTRACT: We require no less than a whole new way of thinking about how we design and build our communities in natural hazard areas—seismic, coastal, and watersheds—if we are to ensure our societies' safety, health, and overall quality of life. Our present approach is inadequate and is inflicting great and growing harm—physically, environmentally, socially, economically, and emotionally—that we can no longer tolerate. The disaster resistant community (DRC) concept, the first and foremost step toward creating quality-of-life communities, was created specifically to provide this new way of thinking. While a great deal has been heard about this term and its accompanying concept, it is, for the most part, not being used effectively. A number of basic questions need to be addressed: What are DRCs? Why are they important? What are the benefits? What is the origin and history of the concept? What is the relationship between a DRC and a sustainable quality-of-life community? And, most importantly, how do we go about creating them? The purpose of this article is to provide the answers to these questions so that the concept can be better understood and used to its fullest potential.

THE CHALLENGE

We continue to experience a growing number of what we have come to call natural disasters—earthquakes, hurricanes, and severe flooding. In a period of four months alone in late 1999 and early 2000 devastating earthquakes struck heavily urbanized northwestern Turkey, Taiwan, and Mexico; Hurricanes Dennis and Floyd ravaged the U.S. east coast with heavy flooding, with particularly devastating results in North Carolina; disastrous flooding occurred in central Vietnam, southeastern Mexico, and Venezuela; and major cyclones struck India and China, causing great damage and loss of life. In Venezuela alone, up to 50,000 lives were lost and 200,000 were left homeless.

These events, more often than not, result in great human, property, and environmental losses, along with social and economic disruption. In 1992 Hurricane Andrew in Florida caused damages exceeding $30 billion, the costliest extreme natural event ever to occur in the U.S. In poorer countries these events can even cause political instability that can paralyze a region or country for years, even decades. The 1972 earthquake in Nicaragua and Hurricane Mitch's impact on Honduras in 1998 are two such examples. While numerous disasters have occurred in our recent history, even more, unfortunately, can be expected in the years to come, and some of them will be in our own backyard. The time has come to change the way these events are perceived and how we go about planning for them.

We still think of these cataclysmic events as ''natural disasters,'' acts of God, over which we have little control. But in fact this is often not the case. More times than not these so called natural disasters are not natural at all, but rather human-made disasters—the result being less of the extreme natural event itself, than that of the inappropriate way we have designed and built our communities and buildings in the hazard-prone areas where they occur.

While traditional emergency management programs and planning—mitigation, preparedness, response, and recovery—are essential, the only real way to minimize the growing human and property losses from earthquakes, hurricanes, and severe flooding is rooted first and foremost in how we design and build our communities in the first place in these hazard-prone areas. We simply can no longer afford the growing loss of life, property, and resources associated with this inappropriate development, particularly when we have the knowledge and wherewithal to make a difference.

WHAT IS A DRC?

Mileti states in the recently published *Second Assessment of Natural Hazards in the United States*, that, ''Unfortunately, no overarching guidance informs development in hazard-prone areas. Instead, a patchwork of innumerable federal, state, and local regulations creates a confusing picture and often reduces short-term losses while allowing the potential for catastrophic losses to grow'' (Mileti 1999, p. 7). Within this statement lies our greatest need—most succinctly expressed—a comprehensive vision to direct our efforts.

The DRC concept was explicitly created to provide this vision, the ''overarching guidance that informs development in hazard-prone areas,'' that Mileti has found to be so wanting. Its purpose is to provide the direction essential to our core mission of minimizing the growing human and property losses from extreme natural events. It is intended

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to serve as a comprehensive master plan for working toward that goal.

A DRC represents the safest possible community that we have the knowledge to design and build in a natural hazard context. It is a means to assist communities in minimizing their vulnerability to natural hazards by maximizing the application of the principles and techniques of mitigation to their development and/or redevelopment decision-making process. While theoretically possible, a DRC is, in reality, a model and a process, an optimal set of goals to work toward, and a set of guidelines to get there. It is also a means for envisioning these goals and a practical framework for implementing them.

The DRC approach must obviously address the structural aspects of a community's buildings and infrastructure through effective building codes, and location considerations through general land-use plans. These two aspects, however, represent only one dimension of the multidimensional sphere necessary for creating such communities. It also recognizes that numerous other nonstructural and functional considerations of the overall community are just as important. The DRC approach is based on the premise that it is impossible to have a truly ''safe building'' without also having a safe overall community and region in which to build and support it.

This relationship between a disaster resistant building and a DRC is an essential consideration. It is important to use such an approach to analyze and plan for the community support systems necessary to ensure safe buildings. This includes such considerations as: fire, police, and medical service; access to public and private transportation systems; relationship to and configuration of adjacent development; relationship and accessibility between workplace, schools, daily needs, and housing, just to mention a few.

Years of research and experience have taught us that there is an integral relationship between how we design/shape our communities and their capacity to minimize the direct and indirect losses from extreme natural hazards. Disaster resistant design must consider

- Relationship of development to natural (ecological and geological) systems
- Development and redevelopment patterns
- Configuration and scale of public infrastructure
- Design, location, and service capacity of community facilities
- Neighborhood and commercial district design
- In general, the overall capacity, functioning, and relationship of the various components and systems of our communities

As Winston Churchill stated within the context of post-World War II reconstruction, ''We shape our buildings (and communities) and then they shape us.'' In a natural hazard context, they shape our capacity for safety, health, and public welfare.

Of course, we didn't get to where we are today (relative to how we design and develop our communities in hazard-prone areas) overnight and we will not be able to change things overnight. It will be a long-term process, but a process that must begin immediately if we are to reduce our losses currently spiraling out of control. Almost every planning and development decision made at the community level has important implications for creating safer communities. The DRC concept provides the much-needed direction for this journey.

Disaster Resistant versus Disaster Resilient

It is often asked why the term ''disaster resistant community'' was chosen as opposed to ''disaster resilient community''? There is a very specific reason. Webster defines resilience as the ''ability to recover from or adjust easily to misfortune or change.'' The synonym that is used is elastic. On the other hand, ''resistant'' is defined as ''the ability to resist.'' Do we want our communities to ''recover from or adjust easily'' to a disaster, which insinuates that one has occurred, or do we want them to ''resist the disaster'' i.e., not to allow the inevitable damage from an extreme natural event to reach ''disastrous'' proportions. In this context, and in the view of this writer, resistant has the most fitting connotation. We want to keep natural hazards from becoming ''natural disasters,'' therefore, resisting a disaster. We want our communities to be hazard resilient and disaster resistant. Along with that consideration, and in our time-byte society, the disaster resistant term has more of an impact (attracts more attention), and is, therefore, more marketable. Marketable in the sense that most people probably prefer to feel resistant to disasters, not just resilient to them.

PRINCIPLES OF A DRC

The DRC concept is built on the foundation of the following ten inherent principles that are essential to its nature and particularly to its successful acceptance and application. Many of the shortcomings of the programs presently in use are a result of not understanding and following these principles. They are summarized below and are further developed and discussed throughout this article.

1. *A holistic and integrated approach*. Everything is interconnected and a holistic, integrated approach is required. You cannot have a disaster resistant building without having a DRC and region to put it in, i.e., to support it. For a community to keep its natural hazards from becoming human disasters, it must be at least as concerned with the overall workings—functioning, connections/relationships, service/use, capacity, and size/scale—of all its systems and components, as it is of the structural integrity of its buildings and the effectiveness of its land-use plan. As important as these two latter concerns are, it is essential to understand that there is much more involved if the most DRCs possible are to be achieved.

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2. *The essential role of the built environment*. The primary vehicle for creating DRCs is the design of the multiscale community built environment (development)—transportation/utility infrastructure, neighborhoods, public and private facilities, commercial development, social and open space infrastructure, etc.—carried out for the most part through the community's planning-development process. To embark on the process of developing a DRC without understanding this essential role of the built environment and its integral relationship to this goal will, for certain, result in failure. This applies as much to the redevelopment of existing communities as to new development.

3. *The interconnection with quality-of-life communities*. The process of creating a DRC must be seen as part of the larger and integrated process of creating sustainable and quality-of-life communities. This is the most effective means to ensure the optimal utilization of the DRC concept and its implementation. The first and foremost concern of a quality-of-life community must be safety and health, characteristics that cannot exist in a community unnecessarily vulnerable to natural hazards and their potentially disastrous consequences. A quality-of-life community is sustainable and by its very design begins by optimizing the protection of its citizens from extreme natural events (followed then by its social, cultural, and economic considerations), thus creating a DRC.

4. *The essential local government role*. If DRCs are to be created, they will have to be created at the local government level. While political and policy support at the state and federal government levels are important, it is only here at the local level where the development and legal tools required to implement such an effort exists, particularly the planning-development process. Almost every planning and development decision made at the local level regarding the built environment (development) has implications for creating less vulnerable and, therefore, more DRCs.

5. *The importance of a grassroots approach*. It is essential to understand and fully utilize each community's unique culture: government, the business community, the media, citizen groups, etc. Using a goal-oriented approach, the principles and techniques associated with developing DRCs must be integrated into the local political, cultural, and planning-development framework already in place in each community. They should be perceived as enhancing existing programs, not creating new ones. A DRC program must be built from the grassroots level, respecting the unique qualities of each community, built from the bottom up, not superimposed from the top down. Knowledge, technical support, and the demonstrated benefits, if needed and asked for, can be provided by the federal and/or state government, but each community must be encouraged and empowered to implement their own program, in their own way.

6. *Enhancing the disaster management function*. The DRC process provides the best means for developing the most effective disaster and emergency management programs possible. This includes risk and vulnerability assessments, as well as optimizing the use of mitigation principles and techniques. It also can serve to enhance the effectiveness of the other components of the disaster management process—preparedness, response, and recovery. And, at a time when more and more resources and players are becoming involved in disaster management, the DRC approach can also provide a valuable planning vehicle for organizing, relating, and optimizing their roles in this process—emergency managers, community planners, health and safety officials, elected officials, and citizen and business groups.

7. *The multibenefit dimension*. There are numerous direct and indirect multibenefits associated with the process of creating a DRC, and they are more times than not essential to its acceptance and adoption. Since disaster management and mitigation concerns are not always at the top of a community's ''full plate'' of priorities, these additional benefits—environmental, social, business-economic, etc.—often become the primary means to motivate and empower communities to actually implement such a program. It is therefore essential to clearly identify and rigorously utilize these broader benefits in the process of creating a more disaster resistant and quality-of-life community. Communities should implement these programs, not because the federal government is giving them money to do so, but rather because of an understanding that it is in their own best interest to do so.

8. *The DRC as basic human right*. Our societal perception of the importance of the kind of communities in which we choose to live, in natural hazard-prone areas, must change. Living in communities as safe as possible from natural hazards, i.e., DRCs, should not be thought of as a luxury or a bonus. Living in such communities should be considered a basic necessity. They should, in fact, be thought of as a basic human right, associated with the inherent health, safety, and public welfare responsibility that our governments—federal, state, and local—are charged with providing. At the very minimum, the use of the state-of-the-art knowledge available on this subject should be required when developing and redeveloping these communities. Such a change in perception, and the subsequent implications, would go a very long way toward this objective.

9. *Minimizing the costs of natural hazards*. The process of creating DRCs is the single most important tool available for minimizing the exponentially growing costs associated with natural hazards. The great majority of direct and indirect losses, and subsequent costs, from natural hazards are related to the built environment, or rather to its inappropriate functional and structural design. They occur either ''TO'' the built environment (direct) in the form of property damage, or ''AS A RESULT'' of the built environment (indirect) in the form of losses associated with functional, social, economic-business, and environmental disruption. We will have to better understand and utilize

the DRC approach if we are to begin to significantly reduce these unacceptable public and private costs.

10. *The core focus of a DRC*. At a time when confusion often occurs between ''ends and means,'' it is essential to stay focused on what must be the core goal of effective disaster management, mitigation, and thus the DRC: to minimize the human, property, and environmental losses, along with the social and economic disruption associated with extreme natural events. All related disaster management programs—preparedness, response, and recovery—must be directly oriented toward and developed with this focus in mind. They must be seen as the means to the end (the goal), not the end in themselves that they often become. While this may all seem obvious, it unfortunately, in many cases, is not. Much of the ineffectiveness of our disaster management planning today, and the continuing growing losses, are a result of the lack of understanding and effective application of this focus. The degree of success in each of these elements can only be measured by the degree they have contributed to this end. The DRC approach provides the comprehensive context to guide this effort.

ROLE OF THE BUILT ENVIRONMENT

The design of the multiscale built environment is the inherent means/language for implementing the principles of mitigation and for ensuring the most effective preparedness, response, and recovery functions possible. It is the only path toward a quality-of-life community and a DRC. This basic truth has, for the most part, been overlooked in the natural hazards field. Only recently, particularly in the *Second Assessment of Natural Hazards in the United States*, has this essential truth begun to emerge into the main stream of the field (Beatley 1998; Mileti 1999).

The built environment is the aggregate human-constructed ''physical plant,'' with its myriad of elements and systems. It includes the buildings where we live, work, learn, and play; the lifelines that connect and service them; and the community and region of which they are a part. It is the roads, utility lines, and the communication systems we use to travel, receive water and electricity, or send information from one place to another. The pipes and transmission lines that carry vital supplies and wastes for use or treatment are other essential elements. Very simply, the built environment comprises the substantive physical framework for human society to function in its many aspects—social, economic, political, and institutional.

Disasters have taught us over the years that there are clear links between the design (functioning, configuration, use, and form) of the systems and elements of the community built environment (transportation/utility infrastructure, neighborhoods, public and private facilities, commercial development, social and open space infrastructure, etc.) and the community's vulnerability to the impacts of extreme natural events.

Examples of these impacts/linkages can include direct damage to or destruction of the built environment, business interruptions, disruption of a community's social framework and institutions, and damage to the natural ecosystems. An appropriately designed built environment that is sensitive to the natural risk conditions with respect to development siting and function, the provision of services, and design and construction will be more hazard-resistant and less vulnerable than one that is not.

Not only will the built environment be more resistant, but economic, social, institutional, and natural resource and ecosystem functions will also be more resistant. This theme—that a key to sustainable hazard mitigation lies in the sensitive siting, organization, and construction of the built environment, at all scales of the community—is repeated throughout this article.

DISASTER RESISTANT, SUSTAINABILITY, AND QUALITY-OF-LIFE

Thomas Jefferson, America's architect of democracy, stated in a letter to James Madison in September 1789 that ''… the earth belongs to each generation during its course, and fully in its own right, no generation can contract debts greater than may be paid during the course of its own existence'' (Padover 1939). It is difficult to imagine a more succinct and meaningful description of the inherent principle of sustainability and quality-of-life, practically based on one hand, while profoundly grounded in an ethical and moral basis on the other. This is the essence of the objective of sustainable and quality-of-life development, and the directly related DRC approach.

To make real progress toward our goal of keeping hazards from becoming human disasters, we must begin to perceive hazard mitigation, or the process of creating DRCs, as a part of a much larger picture, broader, and more integral to the way we do things in this society. That bigger picture is the process of developing quality-of-life communities. Planning such communities represents the framework for planning DRCs. Quality-of-life communities are by their very nature disaster resistant.

Quality-of-life communities, although broader in scope, are for our purposes here, synonymous with ''sustainable communities,'' livable communities,'' and ''smart communities.'' The emphasis may be somewhat different, but the goal of each is basically the same—that of creating the most human/socially, environmentally, and economically viable community possible, one that first optimizes the safety, health, and general well-being of the community and its residents. The goal of creating the safest community possible in a natural hazard context, i.e., a DRC, is an integral aspect of a quality-of-life community, along with social, cultural, economic, and emotional concerns.

Concern Inc. has defined a sustainable community as one that ''uses its resources to meet current needs while ensuring that adequate resources are available for future generations. It seeks improved public health and a better quality of life for all its residents by limiting waste, preventing pollution, maximizing conservation, promoting efficiency, and developing local resources to revitalize the

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local economy.'' A quality-of-life community formulates goals that are rooted in a respect for both the natural environment and human nature and that calls for the use of technology in an appropriate way to serve human needs while respecting the natural environment. Rooted in this principle are the fundamental characteristics of a quality-of-life community (Mumford 1961).

Quality-of-life community development and DRCs are natural partners; therefore, bridges must be built between them to help optimize the goals of each. By the nature of their missions, they must be concerned both with the workings of nature, people, and the relationship between the built environment and the natural environment, as well as the associated economic and social implications. This must be the foundation and essential first step for creating quality-of-life communities, as well as ones that are sustainable and disaster resistant.

OVERCOMING BARRIERS TO DRCs

While protecting losses from potential natural disasters is certainly seen as important to most communities, it all too often takes a back seat to what are seen as more pressing, immediate priorities, such as tax bases, economic development, and traffic congestion. This is probably the basic constraint to implementing the kind of comprehensive mitigation programs that are necessary for DRCs. The only real means to overcome this constraint is to demonstrate that there is something important in it for everyone—government officials, the business community, developers, and environmentalists—and that there are many social, economic, and environmental benefits to be gained with creating a safer community.

This is the essence of the DRC approach, optimizing mitigation while at the same time providing the foundation for a more viable community in general. It is, in effect, creating a safer community as a part of the bigger picture of creating a better quality-of-life.

Traditional approaches to mitigation—flood proofing, elevated structures, structural emphasis, land use, and building codes—although important, are no longer sufficient. A more comprehensive approach is required, one that integrates the principles and techniques of mitigation into the day-to-day development and redevelopment process already in place in almost every community.

DRCs AS INVESTMENT: GROWING VALUE AND MULTIBENEFITS

Appropriately designed communities in a quality-of-life development context have never been more important, considering the cost savings, directly and indirectly, that we have come to understand they represent. If there ever was an example of an ounce of prevention being worth a pound, or as we are seeing in a natural hazard context, many pounds of cure, this is certainly it. From an inappropriately designed roof, to a poorly located or functioning road or water treatment plant, or too much impervious surface cover, each can result in proliferating losses and costs (The H. John Heinz III Center 2000).

Heavy rain after a hurricane can badly damage or destroy the furnishings of a residence with a partially missing roof, leading to the possible displacement of the family, the accompanying emotional stress they experience, and potential tax loss or loss of property value for the municipality in which it is located. Besides the actual cost of repairs, that same damaged roof on a business facility can result in damaged equipment, dislocation of the business, loss of jobs with the accruing ripple effect throughout the employees' lives, as well as the potential loss of taxes to the community.

Properly designed and located infrastructure is particularly critical. A dysfunctional road can have major impact implications for the community: general loss of community productivity; disruption of access for businesses and citizens, keeping residents from getting to work or to their daily activities; keeping emergency vehicles from reaching their destination, with the associated immense health and safety implications; and possible disruption of the food and daily supply needs of the community.

Too many impervious ground surfaces in the form of buildings, concrete/asphalt roads, and parking lots can result in poor drainage and natural absorption capacity, significantly contributing to flooding and subsequent losses. The inappropriate location and design of a water or sewerage treatment facility, a power plant, or a chemical facility can cause service disruption or hazardous discharge that often result in serious health and safety problems, or even the loss of life. The recent results of the 20 in. of rain and heavy flooding from Hurricane Floyd in North Carolina are an excellent example of some of these circumstances.

Along with minimizing the direct and indirect costs of natural hazards, disaster resistant development is also good business. DRCs in a quality-of-life development context are better communities in which to live and do business. A DRC is a well-planned, well-built community, a viable community, an efficient community, a conserving and wise-use community, and an empowering community. It is a community that optimizes its resources—natural, technological, and human—much more effectively, and saves considerable money in the process.

Disaster resistant infrastructure and development enhance the functioning of a community, resulting in more efficient circulation for automobiles, public transportation, and more workable natural and social infrastructure. This all contributes to a more socially, environmentally, and culturally viable community. And at a time when more businesses are becoming interested in the overall quality-of-life for their employees, safer and healthier communities can be more economically viable as well. Thus, to a community that places increasing value on safety, health, economic development, and quality of life, disaster resistant design represents a solid community investment.

These are just a few examples of the benefits associated

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with sustainable and disaster resistant design. They point out the need for communities to give greater attention to how they design and develop their communities in natural hazard-prone areas, and the associated design guidelines and regulation tools needed to accomplish this.

The bottom line is that a DRC process is a win-win situation. If you optimize the approach, applying the principles and techniques over the years, and never experience an extreme natural event, you will still have a more viable community in the end, one that enhances the quality-of-life of the community and its citizens. If you do experience an extreme natural event, the community's losses will be held to a minimum, thus ensuring the fastest, most effective recovery possible.

DESIGNING AND IMPLEMENTING DRCs

Design Determinants

Webster defines determinant as ''an element that identifies or determines the nature of something, or fixes or conditions an outcome.'' It is essential to understanding the design determinants of DRCs if we are to be able to envision, design, and build them.

There are three primary areas of determinants for designing disaster resistant and quality-of-life communities: (1) Natural (ecological and geological) systems and their workings; (2) workings of the systems and components of the community built environment associated with achieving disaster resistance; and (3) more traditional structural requirements of the community's infrastructure and development.

In this context, the inherent characteristics of both the natural and the built environment—capacity, functioning, location and use, connections-interrelationships, density, patterns, and form—become the framework on which the design guidelines and the development regulations needed to create DRCs are built (Sale 1980).

The Natural Systems

The first and foremost step in creating DRCs is to respect and understand the workings of the natural environment, ecologically, hydrologically, and geologically, and then to design and develop the built environment to compliment these systems and their functioning, not interfere with them, as occurs in most cases. This is also the first step in developing sustainable and quality-of-life communities. The majority of human and property losses, and associated social and economic disruption from a natural extreme event, occurs as a result of not following this essential criterion, ending up with inappropriate development that significantly contributes to the problem rather than to the solution. The recent results of Hurricane Floyd in North Carolina provide an excellent example of this. The initial losses and subsequent costs from an extreme natural event are directly proportional to the degree of change that occurs to the natural systems as a result of development.

To design a sustainable and DRC requires understanding the inherent characteristics and functioning of the various systems of nature: drainage-absorption patterns; watersheds; hydrologic systems and cycles; wetlands and marshes; coastal beach and dune systems; slope and soil characteristics; and general flora and fauna habitats. The community built environment should be designed so that its functioning, capacity, scale, and density are in balance with the capacity, scale, and limits of the natural environment of which it is a part (Schumacher 1975). Our mission then becomes, in effect, one of helping nature help us by providing the initial framework and direction for appropriate development (McHarg 1971).

The Built Systems

Once the natural design determinants have been taken into account, we can then turn to the built determinants. What are the disaster resistant implications for the workings of the various systems and elements of the built environment? Looking at them in the context of during and after an extreme natural event, some of these considerations include: infrastructure functioning; service capacity and accessibility of utility services (water, electricity, gas, communication, sewerage treatment, and waste management); relationship of public and private transportation routes; health, safety, and emergency functions; home-workplace connections; use of government-public facilities; food and water supply and availability; and, of course, structural integrity.

DESIGN GUIDELINES AND IMPLEMENTATION

For our purposes, community design is the process of shaping and managing the community built environment (development) as a means to accomplish a community goal or set of goals—in this case, a quality-of-life and DRC. This process requires that much more attention be given to the design of the various built support systems and components of the community: where they are located, their interconnections, how they relate to each other, and to the natural systems of which they are a part. It becomes increasingly important for local government officials and related professionals to look beyond individual buildings to consider the entire built environment—the block, the neighborhood, the community, and the region as a whole; the streets, parks, and other infrastructure that connect them; and other elements that unify and define this complex system. Their role and how they are designed and built will make a significant difference in a community's overall capacity to minimize its physical, social, and economic vulnerability to the forces associated with natural hazards.

Implementing disaster resistant design (optimizing the principles and techniques of mitigation) consists of two parts: (1) Goal-oriented design considerations and guidelines associated with shaping development and redevelopment; and (2) regulatory and administrative tools

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needed to implement these guidelines, such as building codes, zoning, and subdivision regulations.

The following are some of the general design consideration and guideline areas that communities need to address in their planning and development decision-making process in order to develop DRCs:

- The relationship between the built and the natural environments—Designing and building to compliment ecological/geological systems and their workings
- Community-regional support systems and functions for development
- Transportation and utility design (configuration, hierarchy, and location)
- Community development and growth patterns (density, capacity, scale, and size)
- Design and patterns of open space (social/natural infrastructure)
- Housing and neighborhood design
- Individual and building group design (configuration and location)
- Emergency management function design (preparation, response, and recovery) for egress, access, shelter use and location, and staging areas
- Community facility design, location, and capacity (hospitals, fire and police stations, and administrative offices)
- Utilizing maintenance and rehabilitation management as an important mitigation tool

Each of these preceding generic design areas has a specific set of design guidelines for practically achieving their disaster resistant objectives. The following, for example, represent a set of 12 design guidelines for developing or redeveloping transportation systems and facilities in a natural hazard context.

1. Design and configure transportation systems and facilities to minimize functional, social, and economic disruption during and after an extreme event; design to ensure secure home-workplace connections
2. Compliment ecological and geological systems and minimize interference with them
3. Utilize transportation systems to influence overall sustainability and disaster resistant functioning; utilize to guide residential and commercial development to appropriate areas, and in appropriate patterns—scale, density, capacity, and relationship to open space
4. Design to ensure appropriate location, security, and service for potentially hazardous uses and their functioning
5. Provide multiaccess, egress, and decentralization where appropriate for effective functioning and service
6. Design and relate road systems and public transportation systems to compliment and enhance the functioning of both during and after an emergency
7. Design systems in conjunction with utility systems and facilities (water, sewerage, gas, electricity, and communication) when possible to compliment and enhance each other's functioning—minimizing disruption; optimizing service and repair during and after an event; providing disaster resistant water treatment and sewerage treatment facilities and power plants; and for guiding appropriate disaster resistant development in general
8. Design transportation systems and facilities to maximize support service to and between the various elements of the community-region—commercial areas, neighborhoods, public and community facilities, safety/health facilities, etc.
9. Utilize transportation systems-facilities to enhance emergency management functions—preparation, response, and recovery; egress and access; and for connecting and relating critical functions such as shelters, health-safety facilities, food and water supplies, etc.
10. Design development adjacent to transportation systems and facilities to ensure that it does not interfere with their functioning during and after an extreme event
11. Design transportation infrastructure to encourage, relate to, and enhance public and natural open space systems (social and natural infrastructure): for staging emergency functions; community gathering areas; for temporary housing; and for firebreak design
12. Utilize transportation infrastructure as a catalyst for developing new and innovative approaches for disaster resistant and sustainable design:
    a) multiuse safety and security development zones
    b) clustering service and functional uses—for example, combining fire, police, health, and administrative functions; combining and integrating utility systems and facilities (gas water, communication, and electric) to ensure security, efficiency, and cost savings; and multiuse community—need areas (food, basic supplies, and services)
    c) further exploring the role/relationship between safe/sustainable buildings and the safe/sustainable community context.

Much of the program and regulatory framework needed to implement disaster resistant goals and guidelines are already in place at the community level, waiting to be utilized in the day-to-day activities of the community's decision-making process. Communities must learn to use the principles, design considerations, and guidelines documented in this article, and integrate them into this framework. This regulatory framework includes: the comprehensive planning process, zoning and subdivision regulations and building codes, growth management and

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environmental impact statements, performance measurements, development goals and regulations, and the capital budgeting process.

As has been stated, although state and federal support are important, quality-of-life and disaster resistant development will have to take place at the local level as a part of the planning-development process. It is in this context that the actual design of the community takes place, and where almost every decision has significant implications for optimizing mitigation and creating less vulnerable and, therefore, more DRCs. This essential principle is further reinforced by Mileti's statement in the recent *Second Assessment of Natural Hazards in the United States*: ''Disaster reduction should be an inherent part of everyday development processes . . .'' (Mileti 1999, p. 14).

A community that recognizes and grows with respect for natural limitations, protects its ''green infrastructure,'' insists on sound hazard-resistant design and construction for buildings and the community as a whole, and provides positive incentives for private compliance will not only be more disaster resistant in the built environment sense, it will simultaneously be creating a more hazard-resistant economy, social environment, and healthy community ecosystem (The H. John Heinz III Center 2000). To achieve such an outcome, communities must apply these principles both to new development as well as ''retrofitting'' existing development. This is our challenge for the future of mitigation and preparedness as we enter the twenty-first century.

EVOLUTION, PRESENT USE, AND FUTURE OF THE DRC CONCEPT

The term ''disaster resistant community'' and the accompanying concept was first introduced at a Central United States Earthquake Consortium (CUSEC) Natural Hazards Research Symposium, ''Translating Research into Practice,'' held in Louisville, Kentucky, in the spring of 1994 (Geis 1994a). Based on the adage that ''necessity is the mother of invention,'' the DRC concept initially evolved from a perceived need for a more holistic and integrated approach for addressing natural hazard mitigation, the growing human and property losses, and the associated socioeconomic disruption costs from extreme natural events—earthquakes, hurricanes, and severe flooding. The growing recognition that the role of the design of the community-built environment was essential to this effort, but was not being effectively utilized in the traditional approach, was also a primary ingredient in the birth of the concept. A National Science Foundation sponsored study on the architectural and urban design lessons from the 1985 Mexico City earthquakes also represented a major influence in its development (Geis and Arnold 1987; Geis 1988).

While the specific DRC term and concept as presented here is original (CUSEC 1998; Mileti 1999, p. 264), it was influenced by and grew out of a number of evolving forces over the past two decades. These contextual forces included the growing importance of the environmental movement, the evolving recognition of the role of mitigation in emergency management, and the introduction of the concept of sustainability. While each of these movements were influential, the single most important ingredient of the DRC concept was the growing recognition that the comprehensive design of the community built environment was the primary means for minimizing the losses from extreme natural events, and, thus, creating sustainable DRCs.

Other important efforts regarding the relationship between sustainability and mitigation were also going on during this time. The seeds for the recently published *Second Assessment of Natural Hazards in the United States* were being planted by a group of university and federal agency people in Colorado who decided that sustainability should be the contextual theme of such an assessment (Mileti 1999). The subcommittee on Natural Disaster Reduction, located in the White House's Office of Science and Technology Policy, was charged with coordinating federal efforts for the International Decade for Natural Disaster Reduction. That committee also explored the linkage between natural hazards and sustainability as part of their mission. From a number of quarters there was a growing recognition that the fragmented approach to natural hazard mitigation and disaster management simply was not accomplishing what needed to be done.

The DRC concept continued to evolve in 1994 through a series of presentations at various professional meetings in the U.S. by this writer following the CUSEC meeting in Louisville. The first comprehensive paper on the subject was presented at the 1st International Congress of Local Authorities Confronting Disasters and Emergencies held in Tel-Aviv, Israel, October, 1994 (Geis 1994b). That paper emphasized the role of local governments and further developed the connection between natural hazard mitigation, DRCs, and sustainable development.

The professional meeting presentations and the Tel-Aviv paper spurred a growing interest in the subject among various groups, such as local government officials, community planners, and natural hazard professionals. This process resulted in the development and publication of two major papers/articles, further advancing the concept and its application in this country and internationally (Geis and Kutzmark 1995; Geis 1996). These papers further explored the design of sustainable and disaster resistant communities: the role of the existing planning-development decision-making process; the DRC as the process of maximizing the principles of mitigation; framed the DRC as the first and foremost step in developing a sustainable/quality-of-life community; identified the DRC as an essential community investment with a variety of related social, business, cost savings, and environmental benefits; and expanded on the role and use of the multi-scaled built environment.

Over the past three years the writer's work has focused

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on the practical application of the DRC concept to the development and redevelopment process at the local level, including design guidelines, implementation methodologies, progress indicators, and cost-benefit considerations. This work is reflected in a recently published study that looks at the often hidden or unreported costs associated with coastal natural hazards and their implications for more effective vulnerability assessments and mitigation (The H. John Heinz III Center 2000). This study provided the unique opportunity to further explore the potential of the DRC concept and particularly the built environment in a cost-benefit context, and the relationship to social, economic-business, natural resources, and health considerations. The results of this study have greatly enhanced the practical value and applicability of the concept.

Present Use of the DRC Concept

Over the past few years a growing number of organizations and individuals, both nationally and internationally, have adopted the DRC concept and are using it in a variety of ways. In the historical evolution of the concept and its use, a number of these programs have made significant contributions to its development and acceptance. The CUSEC, under the leadership of former director, Tom Durham, was the first organization to recognize the relevance of the concept to the traditional mitigation mission and began to integrate it into their programs in 1995–1996. They developed a very workable model and approach, and applied it to two pilot communities—Evansville, Indiana and Henderson, Kentucky. The initial CUSEC use of the concept represented one of the most effective grassroots use of the concept thus far.

Two other major organizations, the Federal Emergency Management Agency (FEMA), at the federal government level, and the Institute for Business and Home Safety (IBHS) representing the insurance industry, followed soon after with their own related programs in 1996–1997. FEMA's Project Impact Program for developing disaster resistant communities, and the IBHS's Showcase Communities and States Program are important ongoing efforts, and although they have not utilized the full potential of the concept, they have made important contributions to ongoing mitigation efforts throughout the country.

As of early 2000, there were nearly 200 Project Impact communities in different stages of development and with varying degrees of success. IBHS, as an important part of its program, has developed a valuable network of related organizations through Memoranda of Understanding. A number of other groups such as the American Red Cross, the Electric Power Research Institute, the Disaster Recovery Business Alliance, and the American Society of Civil Engineers have also made their own important contributions. The Disaster Recovery Business Alliance Program has been of particular importance in involving the business community.

THE FUTURE—FULFILLING THE VISION

The DRC concept is first and foremost a holistic vision and model for approaching natural hazard mitigation and preparedness as we enter the twenty-first century. It is a vision that looks to the very way we design and build our communities as the central and only realistic means to achieve our goal of minimizing the spiraling costs associated with natural hazards, while creating more quality-of-life communities at the same time. It is also a vision that recognizes this central goal and subsequent solution to be a very long-term process, as much a journey as a final destination. It is, however, a journey that must begin immediately and in full if we are to have safer, healthier, and more economically viable places to live. While it is essential, it will also be difficult and controversial because it calls into question a number of entrenched political and cultural attitudes about land, people, and ways of doing things that are in conflict with what actually needs to be done to achieve a quality-of-life and disaster resistant society. Much has been accomplished in the last two decades, but the surface has only been scratched. To be successful, an even greater commitment from a wider variety of players, and particularly our elected officials, will be necessary. The DRC concept, as much a way of thinking as a means of doing, provides us with the road map for this journey.

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