Introduction to Manufactured Construction

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TRAMCON
Training for Manufactured Construction

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Miami Dade College

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SF SANTA FE COLLEGE

Colorado State University

POLK STATE COLLEGE

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UNIVERSITY OF WISCONSIN STOUT
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INTRODUCTION

1.1 OVERVIEW OF MANUFACTURED CONSTRUCTION

1.1.1 DEFINITION OF MANUFACTURED CONSTRUCTION:

Manufactured construction is a process of producing either building components or complete building structures such as homes, excluding the foundation, in a protected factory environment.

This structure is assembled in an off-site plant and is transported in one or more sections to its final destination. Depending on the type of manufactured construction and the size of the project, most of the building assembly takes place in a factory and the remainder, including the foundation, occurs on the building site. In the residential sector of manufactured construction, there are two basic types of homes assembled in factory settings: **manufactured houses** or manufactured housing and **modular homes**. Manufactured housing must meet U.S. Housing and Urban

Development (HUD) requirements for their construction and is often referred to as **HUD-Code housing.** Modular homes are similar to conventional site-built homes and their manufacture is governed by state regulations.

Manufactured housing and modular homes are assembled in the factory as completed **units**. The size of the units is restricted and must not exceed the standard and legal size and weight limits for a specified portion of road, highway or other transportation infrastructure.

A typical house unit will be between 8 feet and 16 feet wide and range in length up to 80 feet to meet federal and state transportation restrictions. During manufacturing, a unit of manufactured housing or a modular home is also referred to as a **floor** as it progresses through production.

Smaller manufactured or modular homes may be comprised of one floor while larger homes will be assembled on-site from two or more floors. The floor arrangement depends on the specific job. There are various configuration possibilities such as a side-by-side or a stacked layout for a multi-story house.

The completed home is a minimum of 320 square feet (SF) in size. A typical small, single-wide manufactured home, often referred to as a mobile home, may range in size from 500 SF to over 1200 SF. The controlled factory environment and rapid assembly process is

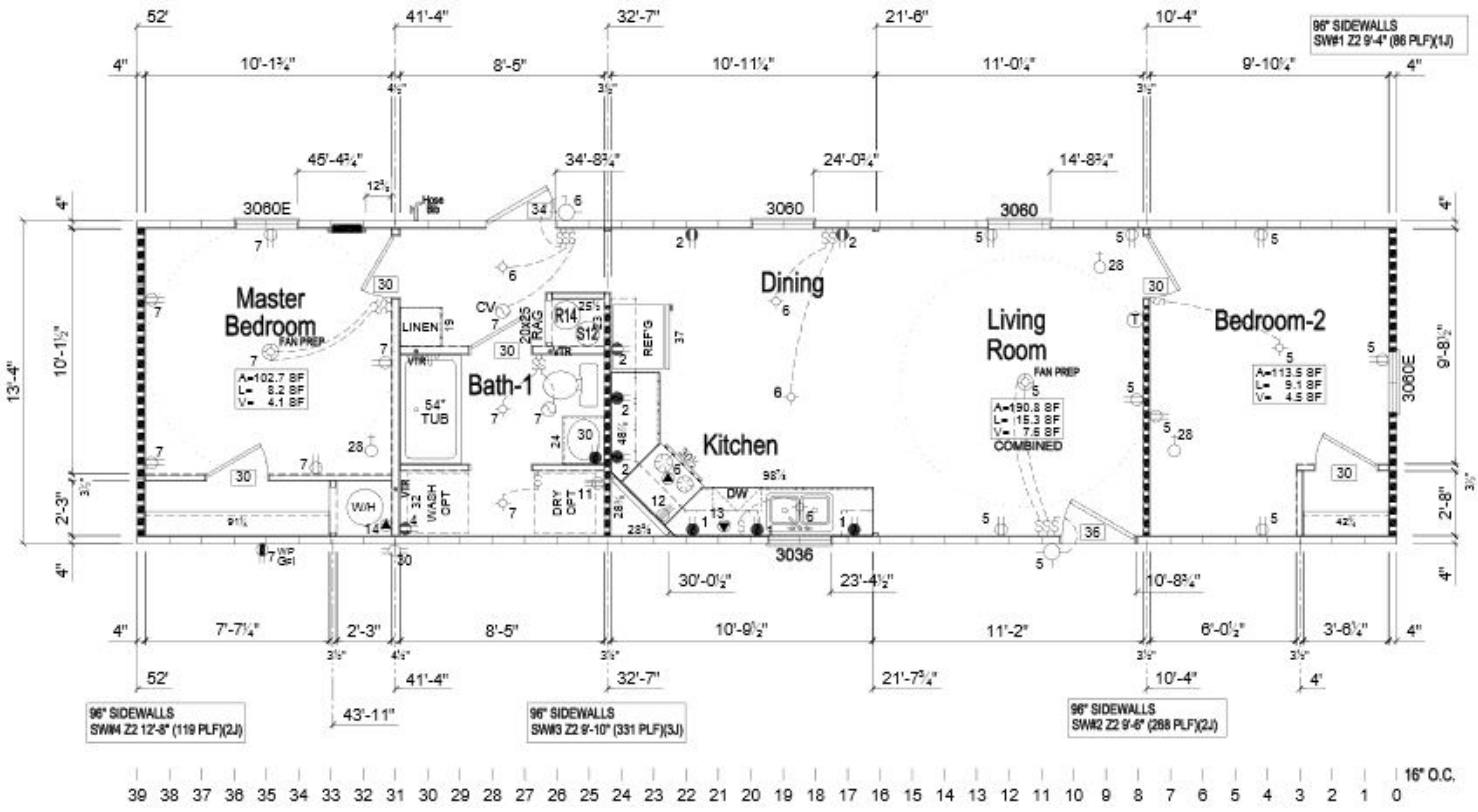

FIGURE 1.1: SINGLE-WIDE MANUFACTURED UNIT THAT IS A COMPLETE HOME

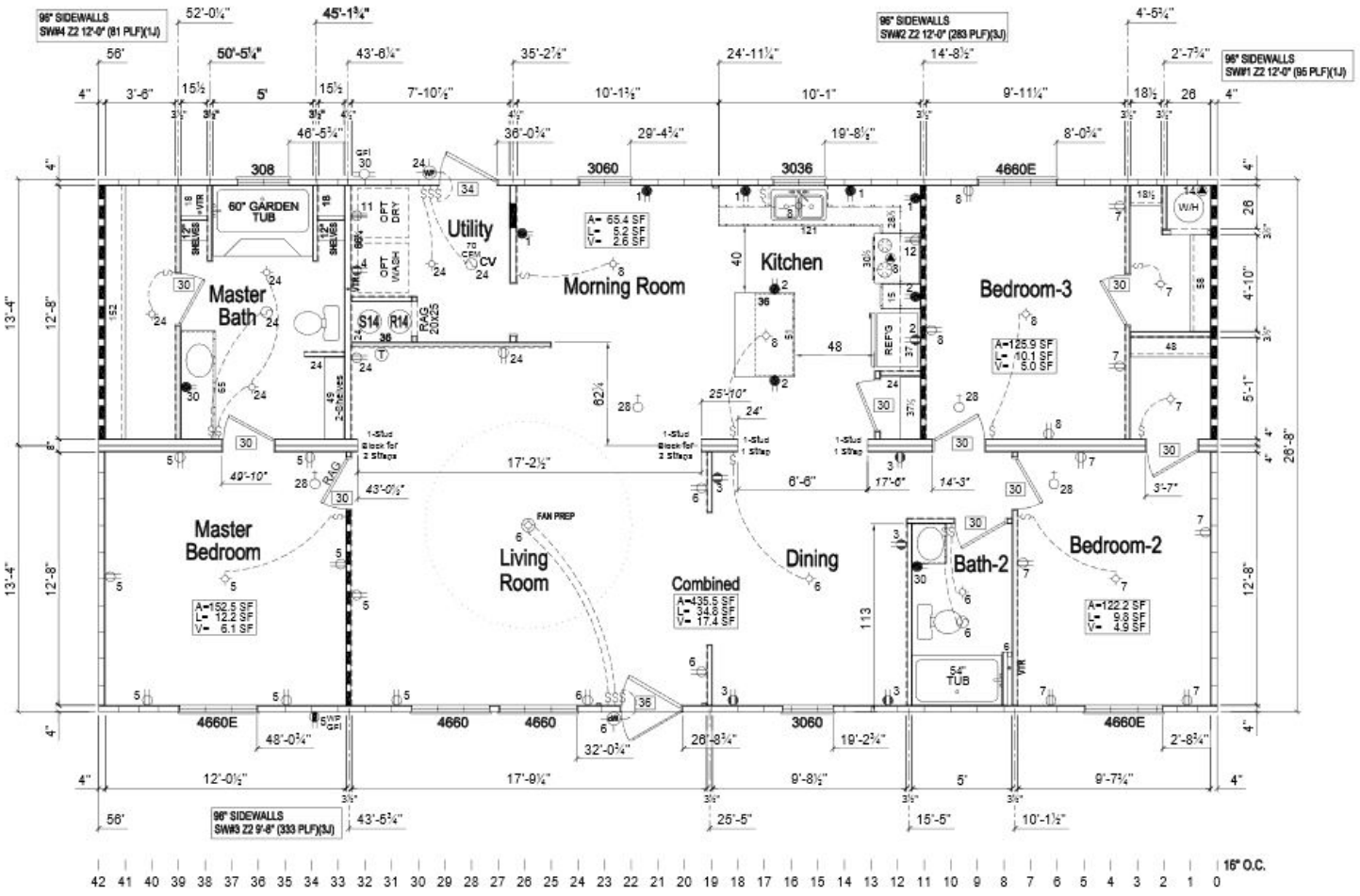

FIGURE 1.2: A DOUBLE-WIDE MANUFACTURED HOME MADE UP OF TWO UNITS

increasing the popularity of manufactured and modular homes in the marketplace, resulting in constant growth in the modular home market. Although modular homes were originally designed for the low-income end-users, they are now becoming attractive to a broader market and there are now far more options in terms of size, style and budget.

Statistics shows that there are thousands of manufactured homes built and installed each year in the U.S. Figure 3 shows the number of manufactured houses sold in the first top 10 states throughout the U.S.

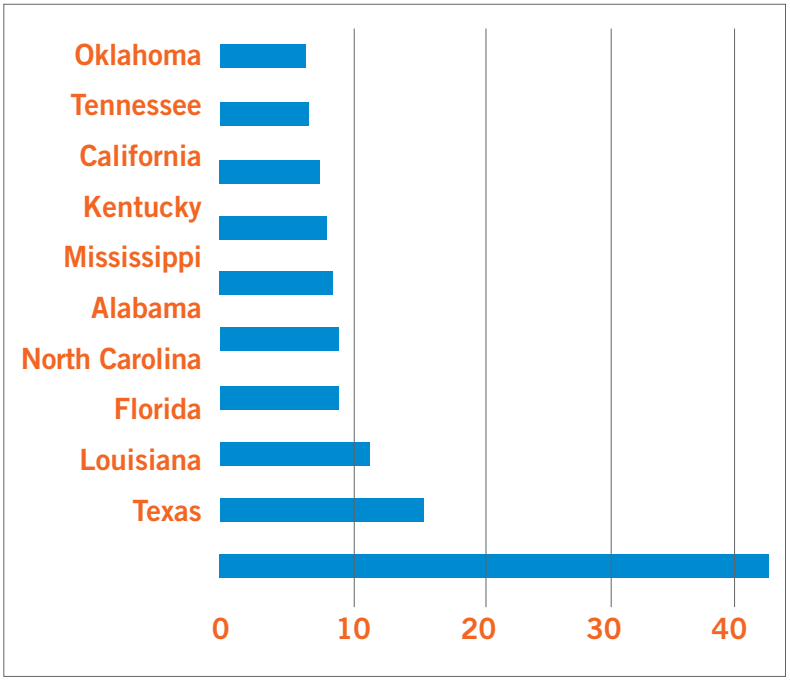

FIGURE 1.3: NUMBER (IN THOUSANDS) OF PRODUCED AND INSTALLED MANUFACTURED HOMES (2011- 2015)

There are three major sectors of home production in the U.S.:

- Site-built homes
- Manufactured (HUD-Code) housing
- Modular homes

In the following sections these three types of home production will be described in order to illustrate the differences in the construction process for each.

REVIEW QUESTIONS 1

1. What is the definition of Manufactured Construction?
2. What sizes of units are typically produced in a factory?
3. What is a unit called during the manufacturing process?
4. Between 2011 and 2015, which state had the highest manufactured home production?

FIGURE 1.4: INSTALLED MANUFACTURED HOMES.

1.1.2 THE EVOLUTION OF MANUFACTURED HOUSING

In the U.S., the dream of a factory-built house became a reality early in the 19th century when houses could be ordered from a catalog and delivered from factory to town by rail. Following World War I, with widespread destruction of housing in Europe and the decimation of its workforce, progressive architects began designing and advocating for the use of factory-built housing. This type of housing could be built with lower skilled labor, under factory controlled conditions and shipped to the site for rapid final assembly.

During the Great Depression (1929-1939), prototype factory-built homes were developed with the idea that they could help prime the national economy. This initiative was stalled by World War II but renewed at its close, when factory-built homes seemed like a suitable solution for meeting two decades of pent-up market demand. However, the effort to create a broad market for factory-built housing soon ran into the reality that housing construction in the United States is controlled by local governments who, along with the site-built housing industry, were opposed to its diffusion.

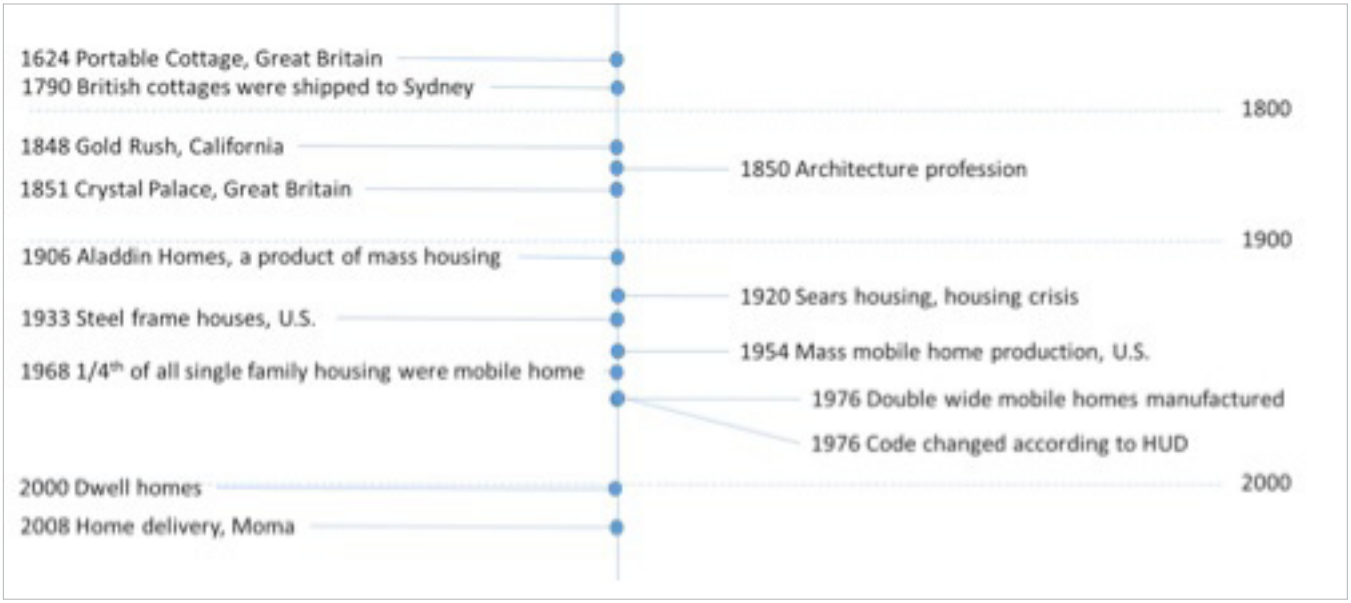

FIGURE 1.5: HISTORICAL STAGES OF MANUFACTURED HOUSING, FROM 1624 TO 2008 (SMITH, 2010)

THE UTILIZATION OF TRAILERS AND MOBILE HOMES

During this same period, one form of factory-built housing was experiencing widespread success, in large part because it was not perceived as "housing."

Beginning in the late 1920s, automobile trailers that could be towed by the family car were being produced in factories. The automobile camping trip was embraced by tens of thousands of U.S. families as a way to return to nature and see the country. Material shortages along with gasoline rationing during World War II largely shut down the market for the manufacturing of automobile trailers, but the industry retooled to produce **house trailers** designed as year-round dwellings for war plant workers.

The government became the primary buyer of this type of housing. However, in the middle of the war years, the government terminated its purchases, in part under pressure from local governments who raised the fear that the temporary war worker homes would become postwar slums in their communities.

After the war, there was a new need for housing that was mobile. Huge federal construction projects for building dams, nuclear power plants and other large infrastructure programs generated a need for dwellings that could provide a comfortable home yet be moved from site to site. Since these were year-round homes, it was desirable to make them more spacious.

In response, the "ten-wide," a 10-foot-wide house trailer, was developed. Its inventor, Elmer Frey, declared that it should be called a **mobile home** because it was a home and it was mobile. The name took, and the wider units soon became the industry standard.

By the mid-1970s, the mobile home industry was producing about a quarter of all the new single-family housing in the United States. By this point, the mobile home was serving

a broad, affordable-housing market and not just itinerant construction workers. It was also being used by retired people who wanted an inexpensive second home located in a park with community amenities.

FIGURE 1.6: MOBILE HOMES ON CHASSES READY FOR DELIVERY

EMERGENCE OF THE MANUFACTURED HOME

The growth in mobile homes was accompanied by concerns about their durability, weather resistance and fire safety. Since they were not legally "buildings," their construction was regulated as vehicles. Calls for improved fire safety standards emerged at both the state and federal levels. The industry tried to address these concerns by developing its own construction code, but it failed to quiet critics because it was voluntary and not closely enforced. Pressure for improved safety ultimately culminated in passage of the Mobile Home Construction and Safety Standards Act of 1974. Under the Act, the U.S. Department of Housing and Urban Development (HUD) was required to promulgate safety codes and establish a system of enforcement.

What became known as the **HUD-Code** effectively made mobile homes the only privately owned building type subject to federal regulation. The HUD-Code provided a foundation for federally guaranteed (Federal Housing Administration, or FHA, and Veterans Administration, or VA) mortgages to be extended to mobile home loans. Those mortgages, which were originally up to 20 years in length, were eventually extended to 30 years for units that were permanently attached to a site and sold as a land-plus-housing package.

By 1980, the once "mobile" home had become largely permanent housing and was referred to as manufactured housing. The Manufactured Housing Improvement Act of 2000 extended federal regulations to include minimum foundation standards. States were required to adopt these standards or develop alternatives that were equivalent or more stringent. States also had to establish consumer protection procedures to resolve disputes about faulty manufacturing and/or set up.

FIGURE 1.7: HUGE TRAILER PARK NEAR EVERGLADES NATIONAL PARK IN FLORIDA

Manufactured homes are only one type of factory-built housing used in the U.S. There are other types such as panelized homes (so-called because they come to the site in panels), component homes (shipped in components and assembled on a site) and modular homes. Of these, modular homes are the most common, and many of the factories that produce manufactured homes also produce modular homes.

The main difference between the two is the legal jurisdiction. Modular homes are built to a state building code rather than to the HUD-Code. A modular home shipped across state lines must meet the standards of the state where it will be sited, whereas a manufactured home can be shipped anywhere in the United States under the same federal code. However, the design must be modified to meet loads and stresses specific to the region of the country where it will be sited (e.g., high snow loads and/or wind loads in specific regions of the country). Although the HUD-Code requires that manufactured homes be built on a steel chassis, modular homes may or may not employ a chassis.

FIGURE 1.8: THE MANUFACTURED HOME IS BUILT FROM INSIDE TO OUTSIDE

FIGURE 1.9: HUD-CODE UNIT ON A CHASSIS

FIGURE 1.10: MAIN PRODUCTION LINE SHOWING SEVERAL STATIONS

FIGURE 1.11: THE FACTORY'S CONTROLLED ENVIRONMENT SPEEDS PRODUCTION, INCREASES PRECISION AND CONTRIBUTES TO SAFETY AND WORKER WELL-BEING

1.1.3 THE PROCESS OF MANUFACTURING A HOUSE

Manufactured housing is assembled entirely under factory controlled conditions. The typical factory has several parallel assembly lines. Assembly begins with moving a steel chassis into the first **station** in the factory. A floor framing panel is constructed on a parallel, "off-line: station, complete with mechanical duct work and chassis. The floor assembly is then flipped over and bolted to the chassis.

As the unit moves down the production line, interior wall panels assembled at off-line stations are attached to the floor panel. Kitchen, bathroom, heating, venting, and air conditioning (HVAC) units are also added at this time. At the next station, exterior walls are added and bolted to the floor and interior wall panels.

Further down, the roof structure is added. Steel straps that tie together the floor, exterior walls and roof are attached. Exterior finishes are then applied. Within a single work day, the final unit rolls out of the end of the factory ready to be shipped to a retail outlet or directly to a home site.

1.1.4 THE ORGANIZATION OF THE INDUSTRY

In the mobile home era, units could be constructed in relatively small factories and shipped within a 1-day transportation radius. Small operations could be competitive in a local area in periods when demand was high because they could keep costs low. When demand was low, they could mothball their operations.

Promulgation of the HUD-Code fundamentally changed the structure of the industry. Enforcement of the Code meant that inspectors had to certify that construction standards were being met at critical points in the assembly process. In addition, design changes affecting structural or mechanical systems had to be approved by HUD as meeting performance standards. Meeting these regulatory requirements made the small manufacturer noncompetitive, leaving an industry increasingly dominated by major manufacturers.

From 1986 to 1991, the manufactured home industry experienced significant market contraction, which further eliminated smaller producers. Emerging from that period, the industry was increasingly controlled by major manufacturers who sought to increase profits from their product line by integrating home financing services and retail sale lots. As of 2010, the industry was dominated by about a dozen large corporations.

TABLE 1.1: NEW MANUFACTURED HOMES SHIPMENTS. SOURCE: U.S. CENSUS BUREAU

New Manufactured Home Shipments in U.S.		
Period	Thousands of Units (2014)	Thousands of Units (2016)
January	4.4	5.9
February	4.4	6.1
March	4.9	7.1
April	5.7	6.7
May	5.7	6.8
June	5.6	7.3
July	5.7	5.3
August	6.0	7.4
September	5.9	7.3
October	6.5	7.2
November	5.0	7.1
December	4.7	7.0

1.1.5 AFFORDABILITY

One of the principal attractions of manufactured homes is their affordability. According to the U.S. Census Bureau, in 2008 the average site-built home in the United States (exclusive of land) cost $88.55 per square foot, while the average manufactured home (including typical installation) cost $41.34 per square foot. The industry's own comparisons suggest that manufactured homes cost between 10% and 35% less per square foot than site-built homes.

The industry argues that it is able to achieve greater affordability by being able to assemble units totally in a factory environment and through the mass purchase of materials, mechanical systems and appliances. Critics counter that these savings also derive from using less skilled and hence cheaper labor and less expensive materials.

REVIEW QUESTIONS 2

1. After World War I, why did progressive architects begin designing and advocating for the use of factory-built housing?
2. What is a mobile home?
3. What is the HUD-Code and why was it established?
4. Explain the manufactured home construction process? How does it differ from on-site construction?
5. What caused the disappearance of smaller manufactured home companies in the late 1980s?
6. Why are manufactured houses generally more affordable than site-built houses?

1.2 TRAINING FOR MANUFACTURED CONSTRUCTION (TRAMCON)

Training for Manufactured Construction (TRAMCON) is a program designed to provide a vetted, educated and trained workforce for the manufactured/modular housing industry. TRAMCON is designed to be delivered by community and state colleges that are typically engaged in workforce training.

The TRAMCON curriculum is organized into four levels and is designed to provide students the opportunity to join the workforce after completion of the second level. They can enhance their training and credentials by completing the third and fourth levels after gaining some work experience. In the context of TRAMCON, entering the program is referred to as an **on-ramp** and leaving training for an internship or permanent employment is called an **off-ramp**. A student can enter and leave training several times to complete the entire TRAMCON curriculum.

TRAMCON provides a program of skills, training and education specially designed for the manufactured construction industry. The manufactured construction industry is rapidly growing due to the significant shortage of on-site construction workers, but lacks the training programs to effectively equip employees for the manufacturing process.

The TRAMCON program is designed to address this important training gap by providing a complete system of nationally recognized certification programs that will be tied to existing manufacturing technology and construction management programs as well as two-year and four-year degree programs offered by state colleges and universities.

TRAMCON offers a series of credentials to systematically train and educate the potential manufactured construction employee. These certifications were developed in close cooperation with the National Center for Construction Education and Research (NCCER) and the Manufactured Skill Standards Council (MSSC).

In Florida, four state colleges and the University of Florida partnered to develop the training and education curriculum and collaborated with industry to facilitate internships and the hiring of TRAMCON graduates.

Florida TRAMCON Consortium

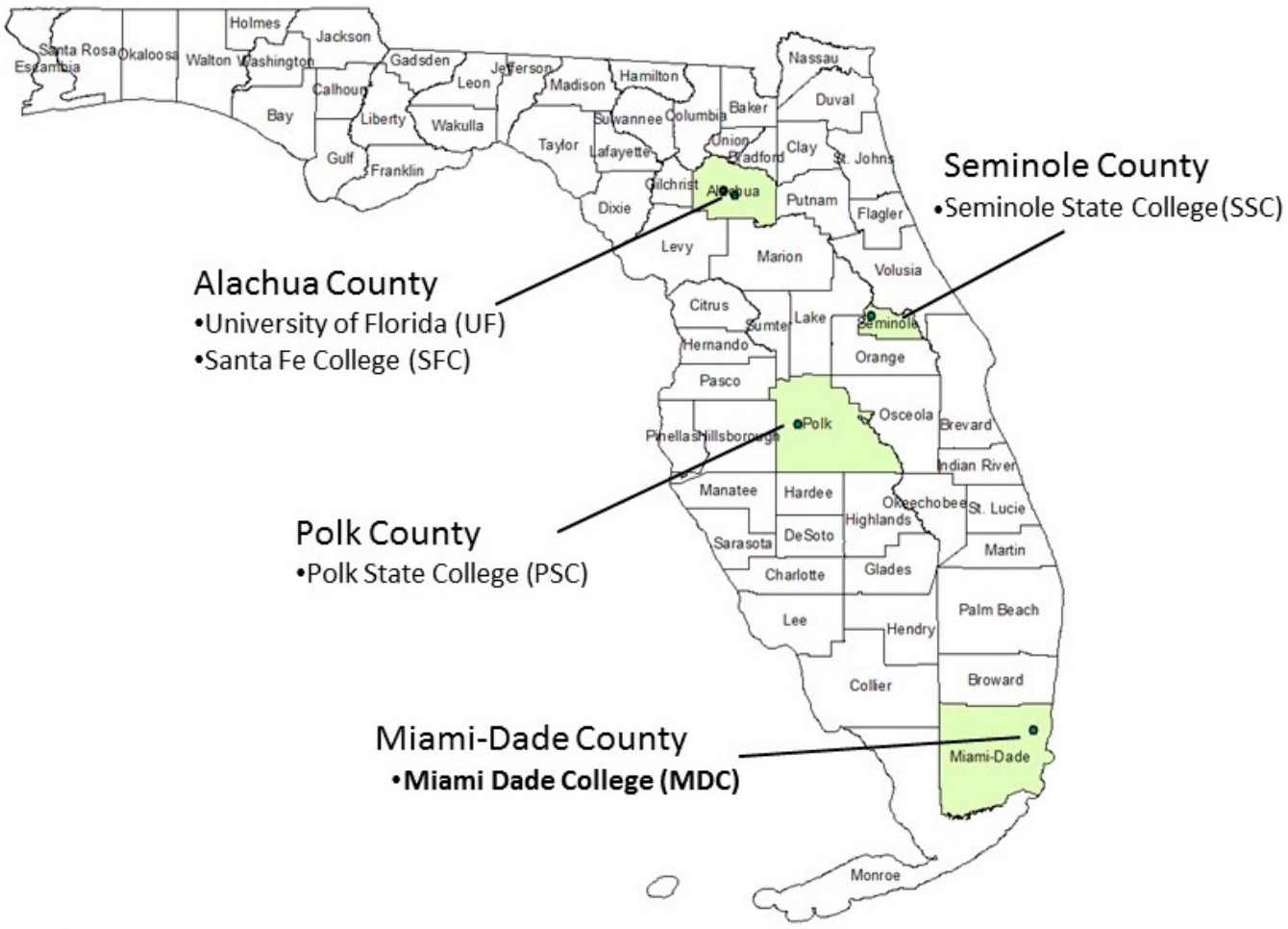

FIGURE 1.12: MEMBERS OF THE CONSORTIUM FOR DEVELOPING THE TRAINING AND CERTIFICATION PROGRAMS IN MANUFACTURED CONSTRUCTION (TRAMCON)

1.2.1 THE FOUR LEVELS OF MANUFACTURED CONSTRUCTION CERTIFICATION

By offering four different levels of certificates, the manufactured construction curriculum provides opportunities to students who are interested in joining the manufactured construction industry and advancing their knowledge and skills. These certificates can be achieved by successfully completing the training programs designed for this purpose.

The four levels of certification are:

I. Manufactured Construction – Foundation Level
II. Manufactured Construction – Basic Level
III. Manufactured Construction – Advanced Level
IV. Manufactured Construction – Supervisory Level

I. MANUFACTURED CONSTRUCTION - FOUNDATION LEVEL:

The **Manufactured Construction Foundation Level** training program provides opportunities for gaining entry level knowledge about manufactured construction and the factory work environment. It consists of three main training segments:

1. Introduction to Manufactured Construction
2. NCCER Construction Core
3. MSSC Production Certification (CPT)

The Foundation Level training program starts with the **Introduction to Manufactured Construction** segment which provides information about the nature of manufactured construction industry and the significant improvements to labor productivity, quality, safety and project duration that can be achieved through Manufactured Construction. This segment also includes modules on the production environment and the manufactured residential construction process.

The Introduction to Manufactured Construction segment is followed by the **NCCER Construction Core (NCCER Core) curriculum** which includes modules that cover topics such as basic safety, communication skills, construction drawings, construction math, materials handling, hand tools, power tools and employability skills. Completing this curriculum gives the trainee the basic skills needed to continue their education in subsequent manufactured construction modules in carpentry, electrical, plumbing and HVAC. The trainee will obtain a 10-hour **OSHA Construction Industry Outreach card** and the **NCCER wallet card** upon successful completion of the NCCER Core and passing the required written and performance tests.

The third component of the Foundation Level training program is the **Manufacturing Production Core Curriculum** that is aligned with the **MSSC Production Certification** (CPT) body of knowledge. The CPT certification program consists of four individual certificate modules: Safety; Quality Practices & Measurement; Manufacturing Processes & Production; and Maintenance Awareness.

► The Safety module provides training on employability skills needed in the manufacturing community (ethics, stress and time management, and team building) plus the baseline knowledge and skills needed to maintain a safe and productive work environment and ensure the safe use of equipment in the workplace.

► The Quality Practices & Measurement module develops foundational knowledge and skills needed to maintain quality and implement continuous improvement processes, and ensure that product and process variances meet quality standards.

► The Manufacturing Process and Production module develops the foundational knowledge and skills needed for the production of Manufactured Construction to meet customer needs while ensuring the manufacturing process meets business requirements. It will cover topics such as the production process, manufacturing instruments, business basics and supply chain.

► The Maintenance Awareness module covers the use and maintenance of manufacturing

and equipment (reliability, lubrication, CNC machines, cranes, forklifts, etc.), tools and assembly and installation methods in the Manufactured Construction industry. It provides the core knowledge of preventive maintenance and enhances existing skills in the identification and performance of equipment maintenance used in the production process.

The MSSC CPT utilizes the Manufacturing Talent Development Institute's (Manufacturing TDI) Manufacturing Fundamentals curriculum. Upon completion of the manufacturing core the trainee will take the test for the MSSC Production Certification to earn the CPT certificate.

II. MANUFACTURED CONSTRUCTION — BASIC LEVEL

The Basic training program provides opportunities for gaining basic level knowledge in carpentry, electrical and plumbing. It consists of two main training segments:

- Manufactured Construction Technology 1
- Basics of Manufacturing Construction

The Manufactured Construction Technologist 1 includes several modules from the NCCER curriculum for carpentry, plumbing, and electricity Level 1. In the carpentry modules, the trainees will learn about building materials, fasteners, and adhesives; hand and power tools, construction of floor, wall, ceiling and roof framing systems, and building envelop systems. The Plumbing modules introduce trainees to plastic piping and fittings; plumbing fixtures; and DWV and water distribution systems. The main purpose of the electricity modules is introducing the National Electrical Code® (NEC®) requirements for residential wiring, device boxes, conductors and cables, residential electrical services, and electrical test equipment.

Upon successful completion of MC Technology 1 curriculum and passing the required written and performance tests the trainee will obtain the NCCER Manufactured Construction Level 1 certification.

The Basics of Manufactured Construction segment covers the detailed process for manufacturing homes and their delivery and assembly. It also covers quality control program and process for manufactured construction including the importance of accuracy and precision in manufactured construction as well as detection of defects and possible product recalls.

III. MANUFACTURED CONSTRUCTION — ADVANCED LEVEL:

The MC Basic certificate holders should complete a minimum of three months on-the-job training in a manufacturing construction plant prior to starting the MC Advanced training program. The MC – Advanced training program provides additional knowledge in carpentry, electrical, and plumbing; and covers several modules in Heating Ventilation, and Air conditioning (HVAC) systems. It consists of two main training segments:

- Manufactured Construction Technology 2
- Advanced topics in Manufactured Construction

The Manufactured Construction Technologist 2 includes several modules from the NCCER curriculum for carpentry, plumbing, and electricity Level 2 as well as modules from NCCER curriculum for HVAC Level 1. In the carpentry modules, the trainees

will learn about exterior finishes, thermal and moisture protection, and drywall installation. The plumbing modules introduce trainees to copper tube and fittings, gas and fuel oil systems, and installation of drains and water heaters. The electricity modules include electrical theory, electrical current, raceway and fittings, hand bending, and electrical lighting. The HVAC modules are introduction to heating, cooling, and distribution systems.

Upon successful completion of MC Technology 2 curriculum and passing the required written and performance tests the trainee will obtain the NCCER Manufactured Construction Level 2 certification.

The Advanced topics in Manufactured Construction segment covers the building standards and applicable codes, energy code, the code enforcement process, and systems testing. It also covers other manufactured construction industries, such as panelized buildings, structural insulated panels, precast concrete buildings, modular prefabricated steel buildings, and truss manufacturing.

IV. MANUFACTURED CONSTRUCTION — SUPERVISORY LEVEL:

This training program provides a great opportunity for the trainees with the MC Advanced Certificate who seek to be promoted to the supervisor level. They should complete at least three months on-the-job training in a manufacturing construction plant after obtaining the Advanced Certificate to start the MC – Supervisor training program, which consists of the following training modules:

- NCCER Project Supervision
- OSHA 30 Hours safety
- Future Topics in Manufactured Construction
- Sustainable Manufacturing

Plant supervisors play a major role in every manufactured construction plant. They are the frontline managers in the plant, directly supervising workers and other station supervisors. They are both the engine and the anchor of the manufactured construction team, driving it toward effectiveness and efficiency, and stabilizing it with consistency and good judgment. In essence, their skills and leadership largely determine whether the manufactured product is built on time and according to plans and specifications. To fill this enormous role, plant supervisors need more than experience in the field. They also need management skills in problem solving, planning, estimating, safety supervision, scheduling, controlling costs and resources, and, perhaps most important, managing people. These are skills most easily acquired through education. The NCCER Project Supervision certification provides the basis for that education. It is a comprehensive, competency-based program that gives both veteran and new plant managers a step-by-step approach to honing their natural abilities, developing essential skills, and generally improving their performance as leaders.

Safety is a fundamental concept, which all levels of employees in the construction industry should know about it. The OSHA 30-hour Safety training program will introduce trainees to the safety rules on job sites. Some of the topics covered in this program includes personal protective equipment (PPE), work zone safety, and fire protection and prevention.

Contemporary issues in Manufactured

Construction covers the following topics:

- Sustainable Manufacturing
- Lean construction
- Automation, advanced technology, and information technology

The Sustainable Manufacturing Guide has been developed to instruct construction supervisors on sustainable construction management, the green building rating systems as it would apply to oversight of their projects and crews, and how to supervise and train their crews so that points aren't unintentionally sacrificed.

Upon completion of Supervisor training program the trainee will obtain the OSHA 30-hour card. In addition, upon successful completion of the NCCER Project Supervisor and passing the required written and performance tests the trainee will obtain the NCCER Project Supervision certifications.

REVIEW QUESTIONS 3

1. What does TRAMCON stand for?
2. What are the four levels of TRAMCON education?
3. What does "on-ramp" and "off-ramp" mean in terms of manufactured construction training?
4. What is an OSHA card? In the Foundation Level, when will the trainee obtain an OSHA 10-hour card?
5. What topics are covered in the Basic Level?
6. After a trainee completes the Supervisory Level, for which positions are they qualified?

1.2.2 CAREER PATHS FOR THE MANUFACTURED CONSTRUCTION WORKFORCE

With the four levels of training detailed above (and summarized in the following chart), the participant can gain the skills they need to enter the Manufactured Construction workforce with focused training and progress to supervisory positions.

Levels of Training			
MC Foundation	**MC Basic**	**MC Advanced**	**MC Supervisor**
Intro to MC	MC Technology 1	MC Technology 2	Project Supervision
Construction Core	Basics of MC	Advanced Topics in MC	30H Safety
Manufacturing Core			Future Topics in MC
			Sustainable Manufacturing
	OJT: 3 Months	OJT: 3 Months	Field Installation Guide

FIGURE 1.13: DIFFERENT LEVELS OF MANUFACTURED CONSTRUCTION TRAINING

During this training, students earn industry aligned certifications from both the construction and manufacturing sectors. Specifically, NCCER and MSSC credentials have been embedded in the modular curriculum.

Two advantages of this certification alignment (outside of the certification benefits to the participant) are that 1) by mapping the certifications into the curriculum, participants can be fast-tracked into the program through demonstration of competency by presentation of the appropriate certification; 2) participants can articulate college credit to Associate of Science (A.S.) degree programs through Florida's statewide industry certification articulation – the **Gold Standard Career Pathways.**

Through the Gold Standard Career Pathways articulations, students will be able to articulate college credit to the Engineering Technology, Construction Management, and Construction technology A.S. degree programs.

1.2.3 CERTIFICATES EARNED DURING THE TRAMCON PROGRAM

In addition to the Foundation, Basic, Advanced and Supervisory level certifications in Manufactured Construction, the students will earn the following national certifications:

Foundation:

- MSSC Certified Production Technician (CPT)
- NCCER Wallet Card
- OSHA 10-Hour Card

Basic Level:

- NCCER Manufactured Construction Technology Level 1

Advanced Level:

- NCCER Manufactured Construction Technology Level 2

Supervisory Level:

- NCCER Project Supervision
- OSHA 30-Hour Construction Industry Card

The NCCER wallet card is given to a student when he or she completes the NCCER Core Curriculum through an Accredited Training Sponsor. A card is also given to anyone who successfully completes an NCCER written assessment. The card number located on the front of the card can be used to track and verify training and assessments on the Automated National Registry.

Table 2 is a summary of the full TRAMCON program including the four levels of training and the certifications that can be earned during this training. Additionally it shows that the TRAMCON training can be articulated as college credit for Associate of Science and Bachelor of Science programs.

TABLE 1.2: CONTENT OF THE TRAMCON CURRICULUM AND CERTIFICATIONS EARNED

Career Pathway for TRAMCON Participants

MANUFACTURED CONSTRUCTION (MC): FOUNDATION			
TRAINING UNIT	**CH**	**CURRICULUM USED**	**INDUSTRY CERTIFICATE OBTAINED**
Intro to MC	27.5	TRAMCON	
Construction Core	72.5	NCCER	OSHA 10-hr card - NCCER wallet card
MFG Prod. Core	120	Manufacturing TDI	MSSC Certified Production Technician (CPT)
TOTAL	**220**		
MANUFACTURED CONSTRUCTION: BASIC			
TRAINING UNIT	**CH**	**CURRICULUM USED**	**INDUSTRY CERTIFICATE OBTAINED**
MC Technology 1	222.5	NCCER	NCCER Manufactured Construction Level 1
Basics of MC	27.5	TRAMCON	
Total	**250**		
ON-THE-JOB TRAINING			
MANUFACTURED CONSTRUCTION: ADVANCED			
TRAINING UNIT	**CH**	**CURRICULUM USED**	**INDUSTRY CERTIFICATE OBTAINED**
MC Technology 2	232.5	NCCER	NCCER Manufactured Construction Level 2
Advanced Topics in MC	27.5	TRAMCON	
Total	**260**		
ON-THE-JOB TRAINING			
MANUFACTURED CONSTRUCTION: SUPERVISOR			
TRAINING UNIT	**CH**	**CURRICULUM**	**INDUSTRY CERTIFICATE OBTAINED**
Project Supervision	85	NCCERI	NCCER Project Supervision
Field Safety	30	OSHA	OSHA 30-Hour Card
Future Topics in MC	30	TRAMCON	
Sustainable Manufacturing	20	TRAMCON	
Field Installation Guide	20	TRAMCON	
Total	**185**		
Two-Year AS Degree in Construction Management, Building Construction Technology or Engineering Technology			
Four-Year Degree in Construction Management or Engineering Technology			

CH = Contact Hours
AS = Associate of Science
MC = Manufactured Construction
TRAMCON = **TRA**ining for **M**anufactured **CON**struction

MSSC = Manufacturing Skill Standards Council
MANUFACTURING TDI = Talent Development Institute
OSHA = Occupational Safety and Health Organization
NCCER = National Center for Construction Education and Research

1.3 REQUIREMENTS FOR THE FOUNDATION LEVEL

1.3.1 ASSESSING WORKER READINESS

Prior to entry the student is required to take the Tests of Adult Basic Education (TABE) test.

TABE is a national 2-1/2 hour test that measures competency in reading, math, and language. It provides the colleges with information to customize the student's learning experience and is a requirement for most career and technical education programs.

1.3.2 ATTENDANCE AND EXPECTATIONS

As soon as the students starts the program, their attendance and involvement in the program are required. Attendance policy will likely vary from college to college. The student is responsible for obtaining information and clarification about the college's attendance policy. However, some segments of the program require perfect attendance and some certifications may not be awarded if there is poor attendance. TRAMCON recommends that students attend and become fully involved in all classes and activities in the curriculum.

1.3.3 NCCER CONSTRUCTION CORE

The National Center for Construction Education & Research (NCCER), in cooperation with publishing partner Pearson, develops and publishes a world-class curriculum created by Subject Matter Experts from industry and academia throughout the United States. Subject Matter Experts ensure that NCCE's exceptional training programs meet or exceed national industry standards. The NCCER curriculum, which includes more than 70 craft areas, is taught worldwide by contractors, associations, construction users, and secondary and post-secondary schools.

The NCCER Construction Core Curriculum is a prerequisite for all the crafts modules and must be successfully completed prior to further crafts training. The Construction Core Curriculum modules cover topics such as Basic Safety, Communication Skills and Introduction to Construction Drawing. By successfully completing the NCCER Core Curriculum, the student attain skills needed to continue the crafts training modules in the Basic and Advanced Levels. The NCCER Construction Core Curriculum modules are:

1. Basic Safety (Introduction to Safety and Accidents, Working from Elevations, Job-Site Hazards, Safety Precautions and Job-Site Hazards)
2. Introduction to Math (Whole numbers and Measurements, Fractions and Decimals, Conversion and Geometry)
3. Introduction to Hand Tools
4. Introduction to Power Tools
5. Introduction to Construction Drawings
6. Basic Communication Skills

1.3.4 MSSC MANUFACTURING PRODUCTION CORE

The purpose of Manufacturing Skills Standards Council (MSSC) Certified Production Technician (CPT_{AE}) program is to recognize, through certification, individuals who demonstrate mastery of the core competencies of manufacturing production at the front-line (entry-level through front-line supervisor) through successful completion of the certification assessments. The goal of the CPT_{AE} certification program is to raise the level of performance of production workers both to assist the individuals in finding higher-wage jobs and to help employers ensure their workforce increases the company's productivity and competitiveness.

The CPT program consists of five individual certificate modules:

1. Safety
2. Quality Practices & Measurement
3. Manufacturing Processes & Production
4. Maintenance Awareness
5. Green Production

Candidates must earn the first four certificates to receive the full CPT_{AE} certification. At this time Green Production certificate is not required for full-CPT_{AE} certification.

1.3.5 STUDENT EVALUATIONS

To achieve the NCCER Construction Core certificate, students must take the performance test and the knowledge-based exam for each module. To obtain the MSSC CPT certification, students must pass exams on the four subjects of Safety, Quality Practices & Measurement, Manufacturing Processes & Production, and Maintenance Awareness.

To obtain the OSHA 10-hour card, students must attend the basic safety module of the NCCER core. No test is required to earn the OSHA 10-hour card. However, any information missing in the NCCER Safety module that is required for the 10-hour card must be covered by the OSHA certified instructor to meet the requirements set by OSHA.

1.3.6 FOCUS ON RESIDENTIAL MANUFACTURED CONSTRUCTION

The focus of TRAMCON educational program at this stage of development is to train a new workforce for the residential manufactured construction. Upon successful completion of this stage, programs for training workforce for other segments of the manufactured construction industry will be developed.

REVIEW QUESTIONS 4

1. What does the abbreviation, NCCER, mean and what is the function of this organization?
2. What does the abbreviation, MSSC, mean and what is the function of this organization?
3. How many certifications can be earned at each of the four levels?

1.4 THE MAIN PRODUCTS OF MANUFACTURED CONSTRUCTION:

The major products of Manufactured Construction are modular homes, HUD homes, park models, panelized buildings, metal buildings, precast structures and Structural Insulated Panels (SIPs). The next sections will briefly describe each of these products.

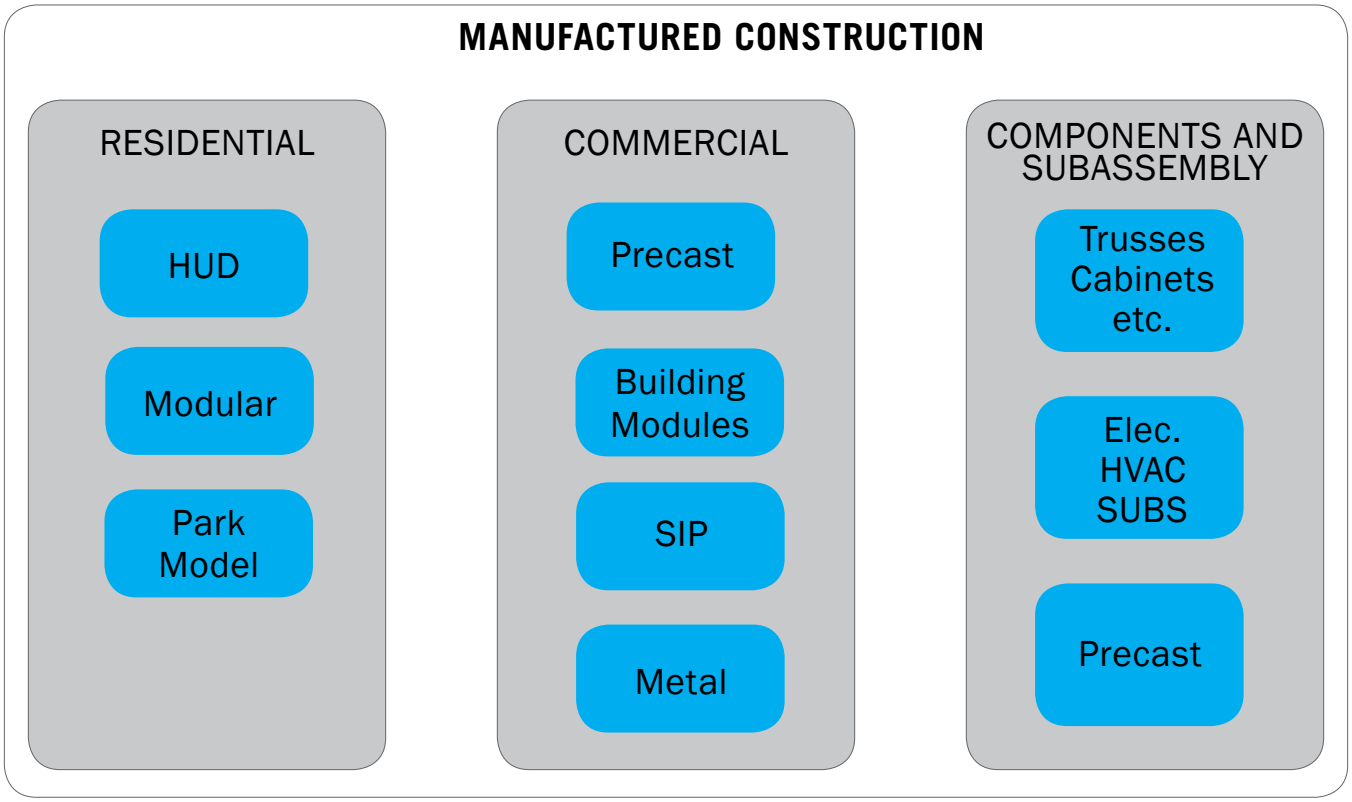

FIGURE 1.14: MAIN PRODUCTS OF MANUFACTURED CONSTRUCTION

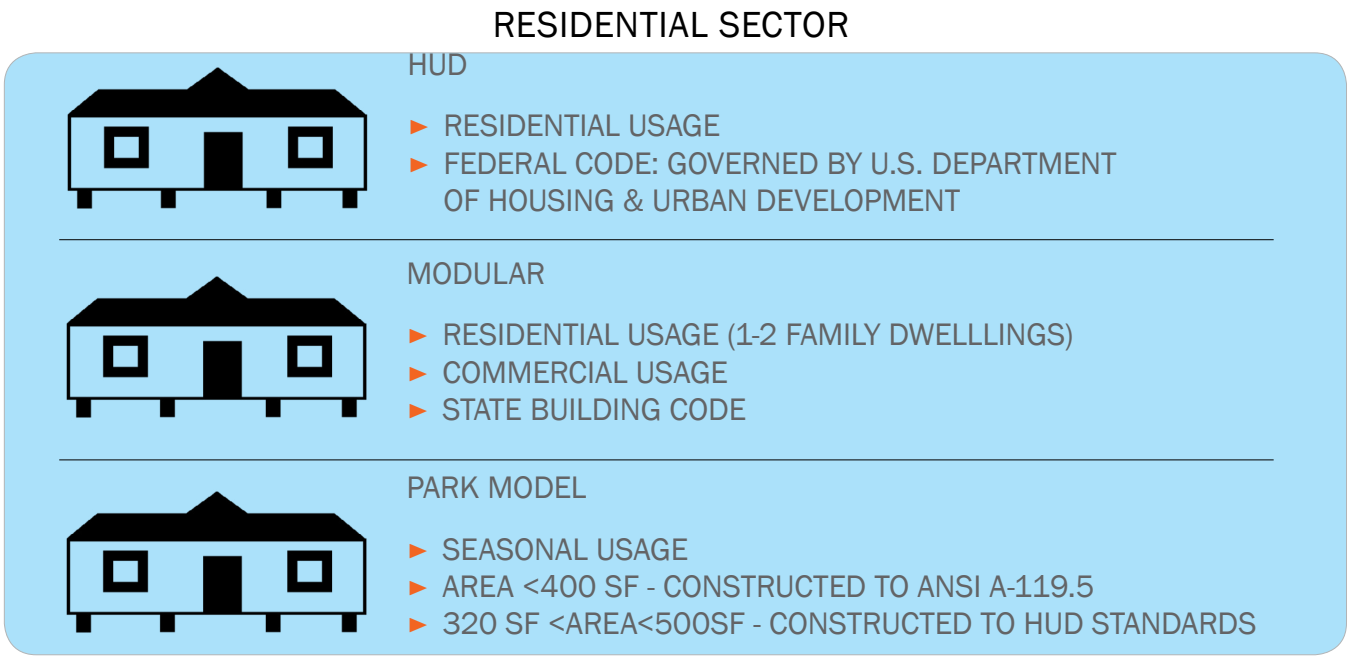

FIGURE 1.15: TYPES OF MANUFACTURED HOUSING AND REGULATORY CODES

1.4.1 MODULAR HOMES

Modular buildings and **modular homes** are sectional prefabricated buildings, or houses, that consist of multiple sections called **modules**.

Modular is a method of construction differing from other methods (e.g. stick-built and other methods such as off-site construction). The modules are six sided boxes constructed in a manufacturing plant and then delivered to the site. Using a crane, the modules are set onto the building's foundation and joined together to make a single building. The modules can be placed side-by-side, end-to-end, or stacked, allowing a wide variety of configurations and styles in the building layout.

Modular buildings, also called **prefabricated buildings,** differ from **mobile homes**, which are also called **manufactured homes**, in two ways. First, modular homes do not have axles or a frame, meaning that they are typically transported to their site by means of flatbed trucks. Secondly, modular buildings must conform to all local building codes for their proposed use, while mobile homes, made in the United States, are required to conform to federal codes governed by HUD (U.S. Department of Housing and Urban Development). There are some residential modular buildings that are built on a steel frame (referred to as on-frame modular) that do meet local building codes and are considered modular homes, rather than mobile homes.

In each U.S. state, for example, Florida, a modular home is built in accordance with the **Florida State Building Code**, the same building code that governs the construction of a traditional site-built home.

Modular homes have many advantages and can be constructed on any residential town lot that is not deed restricted. Modular homes qualify for the same conventional mortgage loans and insurance rates as site built homes.

FIGURE 1.16: MODULAR HOME UNIT BEING ERECTED ON SITE USING CRANES

A modular home is constructed in a factory and transported to the site and contains up to 15% more lumber than a site-built home. This extra lumber adds strength to the structure of the home to allow it to withstand transportation and other loads.

In the State of Florida, the manufacturing of modular buildings is administered under the authority of the Florida Department of Business and Professional Regulations. Some of the regulations pertaining to modular buildings are as follows:

- Building types and usage are not limited provided the designs are in compliance with the governing codes and approved plans and specifications.
- Buildings can be designed for placement at any location within the State of Florida. All construction performed at the plant is inspected at the plant during construction by a state approved, third party inspection agency. All factory and site installed components fall under the inspection authority of the local governmental agency.
- State and third party inspection agency **Insignias** are installed at the electrical panel box of the structure, indicating the building has passed inspection.

1.4.2 MANUFACTURED HOMES (HUD HOMES)

Manufactured homes comply with a Federal Standard 24 CFR PART 3280, more commonly known as the **Manufactured Home Construction and Safety Standards** or the **HUD-Code**. For HUD homes:

- Construction is limited to single family homes.
- Designs are evaluated by a federally approved third party plan review agency known as a DAPIA (Design Approval Primary Inspection Agency)
- In the State of Florida the buildings are also inspected by the State of Florida Department of Highway Safety and Motor Vehicles

An **Insignia** commonly known as a **HUD label** is affixed to the exterior of the home upon completion of the construction.

Manufactured homes are most often found within communities that were developed for this type of housing. However, in northern Florida, where there are several manufactured housing communities, a larger selection of building lots are zoned for manufactured homes.

FIGURE 1.17: MANUFACTURED HUD HOMES READY FOR DELIVERY

1.4.3 PARK MODELS

Park Models are a type of manufactured home ideal for parks, resorts, private vacation homes and retirement communities. They are much smaller than a typical home and designed for shorter-term use. Park Models are built on trailers and are considered to be recreational vehicles. They are transportable and primarily designed for short-term or temporary placement at a destination where an RV or mobile home is allowed. When set up, they are connected to the utilities needed to operate home style fixtures and appliances. They are popular with people for use as a cottage, vacation or retirement home.

In the U.S., Park Models must be under 400 square feet to qualify as a recreational vehicle under federal and state laws. In Canada, Park Models must be under 540 square feet in order to qualify as a recreational vehicle. If they are larger, Park Models would be considered to be a manufactured home and be subject to different taxes and regulations. Many units feature slide-out or tip-out bays, which collapse into the unit for travel and then expand outward when parked to increase overall living space. All floor plans are designed to remain under that limit when adding bays. If buyers want to stretch a plan, then the width may need to be narrowed. If they want to widen a plan, then the length has to be shortened.

A Park Model usually has steel tie-down straps for attachment to ground anchors. These are often required to satisfy local zoning and/or mobile home park regulations.

FIGURE 1.18: PARK MODEL INSTALLED

FIGURE 1.19: PARK MODEL BEING MOVED WITH A CRANE DURING INSTALLATION

The following points apply to manufactured Park Models:

- They must be under 400 SF floor area.
- They are not designed to be used as a permanent dwelling but as temporary living quarters for recreational, camping, travel, or seasonal use. An RV shall be moved every 180 calendar days.
- Designs are evaluated by a third party agency
- Construction is inspected by a third party inspection agency
- Many manufacturers are members of the Recreational Park Trailer Institute Association (RPTIA) and affix the RPTIA insignia to the home
- Park Trailers are assigned a Vehicle Identification Number (VIN)

The following points apply to manufactured Park Trailers that comply with Federal Standard 24 CFR PART 3280 (HUD-Code):

- The size must be between 320 SF and 500 SF
- They are not designed to be used as a permanent dwelling but as temporary living quarters for recreational, camping, travel, or seasonal use. An RV shall be moved every 180 calendar days.

REVIEW QUESTIONS 6

1. What are the main products of manufactured construction? Describe each briefly.
2. What is the definition of "modular"?
3. What is the difference between HUD homes and modular houses?
4. What are Park Models and what are their size limitations?

1.4.4 METAL AND MODULAR STEEL BUILDINGS

Modular steel construction is a term describing the use of factory-produced, pre-engineered, steel building units delivered to the site and assembled as large volumetric components or as substantial elements of a building.

The modular units may form complete rooms, parts of rooms, or separate highly serviced units such as toilets or lifts. The collection of discrete modular units usually forms a self-supporting structure in its own right or, for tall buildings, may rely on an independent structural framework.

The advantages of modular steel construction are:

- the economy of scale resulting from repetitive manufacturing,
- rapid on-site installation (6-8 units per day),
- high levels of quality control in factory production,
- lighter weight, leading to foundation savings,
- suitability for projects with site constraints and where methods of working require more off-site manufacturing,
- limited disruption in the vicinity of the construction site,
- useful for building renovation projects such as roof top extensions,
- excellent acoustic insulation due to double layer construction,
- adaptable for future extensions,
- ability to be dismantled easily and moved if required,
- robustness due to attaching the units together at their corners, and
- stability of tall buildings provided by a braced steel core.

FIGURE 1.20: MODULAR HOSPITAL BUILDING INSTALLATION OF OPEN SIDED MODULES (IMAGE COURTESY OF YORKON)

1.4.5 PRECAST CONCRETE PANELS AND STRUCTURES

Precast concrete structures are designed and manufactured off-site and erected on-site. These structures are durable and have many benefits. The concrete surface design is suited for direct decoration and exposure. Better quality architectural and structural components, large volume supply capacity, solid room-sized slabs with prefinished ceiling surfaces, efficient delivery, high-speed production and refitted window options are just a few advantages of using this system.

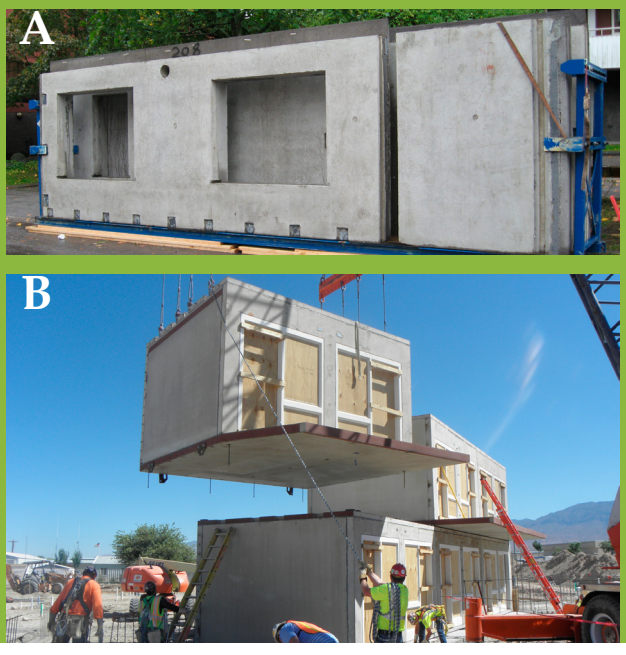

FIG. 1.21: EXAMPLES OF PRECAST STRUCTURES.

(A) - PRECAST CONCRETE COMPONENTS. (B) - PRECAST CONCRETE MODULES. (C) - MOSHE SAFDIE'S EXPERIMENTAL HOUSING COMPLEX MADE OF PREFABRICATED MODULAR CONCRETE UNITS.

1.4.6 STRUCTURAL INSULATED PANELS (SIPS)

Structural insulated panels (SIPs) are a high performance building system for residential and light commercial construction. The panels consist of an insulating foam core sandwiched between two structural facings, typically varying thickness of oriented strand board (OSB). They can also have different sheathings such as fiber cement, metal, gypsum board, or other material on one side. They are often used to infill an enclosure for larger steel or concrete frame structures. SIPs are manufactured under factory-controlled conditions and can be fabricated to fit nearly any building design. The result is a building system that is extremely strong, energy efficient and cost effective. Building with SIPs can save time, money and labor. When paired with CNC technology SIPs can be laid out digitally and cut with precision.

FIG. 1.22: STRUCTURAL INSULATED PANELS BEING ASSEMBLED INTO A BUILDING

1.4.7 PANELIZED CONSTRUCTION

In **panelized construction**, floor and wall panels are manufactured in a factory and assembled on the building site. Panels may be conventionally-framed stud walls in modular sections or structural panels consisting of a sandwich of plywood (or oriented strand board) on either side of solid foam board insulation. Panelized construction makes use of wall, floor, ceiling, or roof "panels" which have been framed off-site and brought to the site by truck. While there are several types of panelized building systems to choose from, each begins by constructing the home's essential structural components in a controlled facility.

FIGURE 1.23: PANELIZED CONSTRUCTION

1.4.8 PREFABRICATED TRUSSES AND WALL PANELS

Prefabricated trusses are manufactured structural components typically composed of five or more triangular units constructed with straight members whose ends are connected at joints referred to as nodes. Prefabricated wooden trusses provide a lightweight solution for supporting the roof of manufactured and modular homes and these are manufactured in factories and shipped to building sites. Similarly there are companies who manufacture wall panels and then transport them to the construction site instead of building them on site. The savings result from the controlled factory conditions which permit the use of automation and provide a high level of precision in their fabrication.

REVIEW QUESTIONS 7

1. What is modular steel construction? What are the advantages of this type of construction?
2. What is a precast concrete structure?
3. What is a SIP and what are its components? What type of buildings can they be used for in construction?
4. In panelized construction, where does the assembly of components take place?

1.5 THE MANUFACTURED CONSTRUCTION INDUSTRY ASSOCIATIONS

An industry association is an organization founded and funded by trade industries. Similar to any other business group, Manufactured Construction associations participate in public relations activities and support collaboration between companies to standardize rules and by-laws and to influence public policies in this sector.

FIGURE 1.24: VARIOUS MANUFACTURED CONSTRUCTION INDUSTRY ASSOCIATIONS

1.5.1 MANUFACTURED HOUSING INSTITUTE (MHI)

MHI is the national trade organization representing all segments of the factory-built housing industry. MHI serves its membership by providing industry research, promotion, education and government relations programs and by building and facilitating consensus within the industry.

1.5.2 MODULAR BUILDING INSTITUTE (MBI)

Founded in 1983, the Modular Building Institute (MBI) is the international non-profit trade association serving modular construction. Members are manufacturers, contractors, and dealers in two distinct segments of the industry — Permanent Modular Construction (PMC) and Relocatable Buildings (RB). Associate members are companies supplying building components, services and financing.

It is MBI's mission to expand the use of off-site construction through innovative construction practices, outreach and education to the construction community and its customers and recognition of high quality modular designs and facilities.

1.5.3 MODULAR HOME BUILDER'S ASSOCIATION (MHBA)

The Modular Home Builders Association (MHBA) is the only national organization dedicated exclusively to serving the modular home builders and manufacturers. In an effort to improve construction productivity and efficiency, the MHBA promotes the advantages of modular construction to builders, government agencies and the general public. MHBA also advocates at the state and federal level to ensure a fair and competitive playing field for the industry.

1.5.4 MANUFACTURED HOUSING ASSOCIATION REGULATORY REFORM (MHARR)

The Manufactured Housing Association Regulatory Reform (MHARR) is a national trade association representing the views and interests of producers of manufactured housing regulated by the U.S. Department of Housing and Urban Development.

1.5.5 STRUCTURAL BUILDING COMPONENTS ASSOCIATION (SBCA)

Structural building components include a wide variety of factory manufactured construction elements such as roof trusses, floor trusses and wall panels. Components are delivered to the job site where framers install them along with permanent bracing to create the overall structural system. SBCA is a national industry trade association that represents the interests of their members in front of policy makers and for the resolution of a wide variety of technical and non-technical issues.

1.6 FEDERAL & STATE INSPECTION PROCESS FOR HUD AND MODULAR PRODUCTS

HUD requires housing to be decent, safe and sanitary. Inspections are designed to ensure there are no deficiencies in the manufacturing of modular and manufactured homes and that they have been built to high quality standards.

Manufactured or HUD homes are built to a federal building standard, the **Federal Manufactured Home Construction Safety Standards**. The HUD-Code regulates the design, construction, structural durability, transportability, fire resistance and energy efficiency of a home. It also prescribes performance standards for the mechanical, plumbing and electrical systems. Manufactured homes are built and shipped on a permanent chassis.

Modular homes are constructed to the same code as site-built homes with requirements set forth by state and local government for the specific locality. Model building codes serve as the basis for most state building codes. Examples include the International Residential Code (IRC), Uniform Building Code (UBC) and the National Electrical Code (NEC). Modular homes may be built on a permanent chassis or on a returnable carrier system.

IPIAs and **DAPIAs**. Production Inspection Primary Inspection Agencies (IPIAs) are HUD-approved, state and private third-party agencies that inspect a manufactured home at various stages of production. **Design Approval Primary Inspection Agencies** (DAPIAs) are HUD-approved, third-party agencies that review the manufacturer's designs to ensure the plans are consistent with HUD Standards.

Manufacturers contract directly with a state or local third party agency and pay for the design review and home inspection services. The following link provides list of IPIA and DAPIA agencies:
http://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/rmra/mhs/mhsid#FL

Enforcement and Inspection. Uniformity and consistency can be maintained in the federal government enforcement system because of two key factors.

First, the inspections take place in the factory during each phase of manufacturing, in conjunction with the manufacturer's own in -plant inspection and quality assurance teams. This allows for more thoroughness since time is spent inspecting homes rather than traveling to inspection sites. Efficiency is increased because travel time is limited and paperwork is minimized.

Second, consistency is maintained because fewer people inspect the manufactured homes at each factory. The enforcement procedure is much less susceptible to individual interpretations, as is the case for on-site home construction inspections in every jurisdiction across the country.

Nature of Program: HUD issues and enforces appropriate standards for the construction, design, performance and installation of manufactured homes to assure their quality, durability, affordability and safety. The construction and safety standards preempt state and local laws that are not identical to the

federal standards; they apply to all manufactured homes produced after June 15, 1976. HUD may enforce these standards directly or through states that have established state administrative agencies in order to participate in the program.

HUD may inspect factories and retailer lots and review records to enforce such standards. If a manufactured home does not conform to federal standards, the manufacturer must take actions specified by HUD, including possibly notifying the consumer and correcting the problem.

HUD also administers programs regulating the installation of the homes, reviews the installation standards programs and reviews the administration of state dispute resolution programs in 35 states. It also administers a federal installation program and a HUD dispute resolution program in the other 15 states.

REVIEW QUESTION 8

1. Name three manufactured housing associations.
2. Name six manufactured construction companies located in Florida.
3. What is the main purpose of the HUD inspection process?
4. What are the functions of DAPIA and IPIA?

MODULE 2

THE MANUFACTURED RESIDENTIAL CONSTRUCTION PROCESS

2.1 MANUFACTURED CONSTRUCTION VS. SITE-BUILT CONSTRUCTION

2.1.1 THE PROCESS OF BUILDING A SITE BUILT HOME

Site-built housing is subject to a wide variety of state and local building codes. Building codes vary by state and region and are often dependent on the climatic conditions in the area where the construction occurs. For example, in Florida there is strong emphasis on addressing high winds, especially in coastal zones. As a general overview, the following are the steps in constructing a site built home.

FIGURE 2.1: THE PROCESS OF BUILDING A SITE BUILT HOME

STEPS TO PREPARE THE SITE AND BUILD THE FOUNDATION:

1. Clear the site.
2. Excavate for the installation of septic system (if needed).
3. Level the site.
4. Excavate for foundation work.
5. Pour the concrete footings.
6. Install plumbing system, water system and electrical chases.
7. Pour the slab-on-grade.

INSPECTION 1

A building inspector checks the foundation and elements in the floor to ensure that the construction meets the requirements of the building code before it is covered with concrete.

STEPS IN ROUGH FRAMING AND ROOFING

The framing includes the shell or skeleton of the building such as floor, walls and roof systems.

1. Frame the floor, walls, roof and staircase.
2. Apply OSB sheathing onto the framing.
3. Install windows and doors.
4. Cover the sheathing with vapor barrier.
5. Place roofing.

STEPS IN ROUGH-IN PLUMBING, ELECTRICAL AND HVAC

1. Run pipes and wires through the interior walls, ceilings and floors.
2. Run sewer lines, vents, water supplies for the fixtures.
3. Install bathtubs and shower units.
4. Install ductwork, piping and insulation for HVAC.
5. Install electrical outlets, lights, switches and panels.
6. Install wiring for telephones and cable for TV.

INSPECTION 2 FOR ROUGH-IN FRAMING

Rough-in framing is inspected for compliance with the building codes.

INSPECTION 3 FOR ROUGH-IN PLUMBING AND ELECTRICAL SYSTEMS

The rough-in plumbing and electrical installations are checked to ensure they comply with the building code.

INSPECTION 4 FOR ROUGH-IN HVAC SYSTEM

The rough-in of the HVAC system is inspected for its compliance with the building code.

INSTALL INSULATION AND DRYWALL

After the rough-in inspections are completed and any deficiencies remedied:

1. Install wall insulation (fiberglass, mineral wool, cellulose, or foam) ,
2. Hang drywall
3. Tape the seams and spackling

STEPS TO COMPLETE THE INTERIOR AND EXTERIOR FINISHES

1. Apply primer coat painting.
2. Install of exterior finishes such as siding, bricks, stucco or other exterior finishes.
3. Install interior doors.
4. Install baseboards and door casings.
5. Install window sills and moldings.
6. Install stair bannisters and decorative trimming.
7. Install cabinets and vanities.
8. Install the fireplace.

9. Apply final coat painting.

STEPS TO COMPLETE FLOORING, COUNTERTOPS, EXTERIOR GRADING AND LANDSCAPING

1. Install tiles, carpet and/or wood flooring
2. Install countertops
3. Grade the site
4. Prepare the site for landscaping

COMPLETION OF MECHANICAL, PLUMBING AND ELECTRICAL

Installing the mechanical trimming, light fixtures, outlets, switches, sinks, toilets, faucets

COMPLETION OF FINAL FINISHES AND LANDSCAPING

Installing mirrors, shower doors, carpeting, landscaping

INSPECTION 5 – FINAL INSPECTION

The final inspection is performed by building-code officials who issue a certificate of occupancy (C.O.) if there are no defects. In the case of any defects, the building official makes a list of items for corrective action and re-inspects these items when corrective actions have been made.

FINAL WALK-THROUGH

Examining the quality of the finishes by the owner before the final move-in.

2.1.2 LAND DEVELOPMENT FOR ON-SITE CONSTRUCTION

Site-builders are frequently involved with land development which is critical to the overall new home production process. Without a steady stream of finished building lots becoming available, new construction activity would essentially come to a standstill. The land development process requires consideration of zoning requirements; federal, state and local environmental issues; and community planning issues. For typical site-built residential construction, three basic options exist: developer-only, developer/builder and builder only.

Developers-only are entrepreneurs who develop land by buying and subdividing it into lots and providing the necessary initial infrastructure. They eventually sell the developed lots to builders or would-be home owners who contract with their own builders. In this option, the developer would be responsible for obtaining any required environmental, zoning, or other permits for grading the land, constructing roads, installing water, sewer, gas, electricity and storm water systems. This category of developer does not become involved in home construction. In extreme cases the process of obtaining required approvals may take years, during which the land developer bears the carrying costs on the land for interest and taxes as well as the cost of engineering, planning and execution of the development activities.

Developer/builders perform all of the development-related activities and build houses on some lots. Other lots may be sold to builders or prospective homeowners who are responsible for arranging their own construction.

Builders-only purchase finished lots from land developers or developer/builders. They

secure permits and construct homes on individual lots, either presold or for eventual sale. Under this arrangement the builder carries the cost of the developed land from the time the lot is purchased until the completed home is sold.

Builders who construct homes on land they own with an expectation of eventual sale are termed **merchant** or **speculative builders**. Builders who build on land owned by a home buyer to the buyer's specifications are often called **custom builders.**

REVIEW QUESTIONS 9

1. Name the inspections in the process of building a site built home.
2. What does C.O. stand for?
3. Name the steps in the rough framing and roofing processes for site built homes.
4. Who is responsible for obtaining the permits for site built homes?
5. What is the difference between developer/builder and builder only for site built construction?
6. What is a speculative builder?
7. What is a custom builder?

2.1.3 THE PROCESS OF MANUFACTURING A HOME AND INSTALLING IT ON SITE

STEPS IN PREPARING THE SITE AND BUILDING THE FOUNDATION

1. Clear the site
2. Excavate for and installation of septic system (if needed)
3. Level the site
4. Excavate for foundation work
5. Pour the concrete footings

STEPS IN THE DEVELOPMENT OF A MANUFACTURED CONSTRUCTION HOME

1. Take customer order
2. Use a standard model or draw a custom made plan
3. If a custom-made plan, apply for approval from third party agencies (DAPIA)
4. Create construction drawings
5. Order materials
6. Build/order the required size of chassis
7. Build the flooring
8. Build the interior walls & the exterior side walls (offline or on fixed station)
9. Build roof framing (offline)
10. Install exterior wall sheathing
11. Blow insulation in the roof
12. Put decking on roof
13. Install roof fencing, soffit, fascia
14. Install windows and doors
15. Install felt paper & shingles
16. Apply exterior siding
17. Apply interior trimming
18. Install tiling
19. Install electrical finishing
20. Build, install cabinets and millwork
21. Perform cleanup
22. Prepare the kit for on-site installation

2.1.4 LAND DEVELOPMENT AND INSTALLATION FOR MANUFACTURED HOUSING (HUD)

HUD LAND DEVELOPMENT

Companies that produce manufactured homes have not historically dealt with **land development** or **retailing** and, as a result,

have not borne any of the costs or captured the profits associated with land development.

Obviously every home needs to be placed in some suitable location and the HUD-Code sector has dealt with this requirement in several ways. Full-service or turnkey retailers of HUD-Code homes buy, develop and sell land, and can package the ownership or rent of lots in scattered locations or in community parks as part of the home sale. They can also sell to customers who own their own land. Retail dealers can accomplish this since they arrange for most of the consumer financing of manufactured homes through individual banks and financing companies. Other retail dealers either sell manufactured homes to customers who already own land, or can direct customers to owners of lots developed and zoned for manufactured homes, either scattered or located in community parks.

Producers of manufactured homes are expanding their role in providing housing to consumers. Large manufactured home producers, including Clayton Homes and Oakwood, have already integrated to the retail level. Clayton, for example, engages in retailing and financing manufactured homes through 63 retail centers and is involved in land development through the operation of 67 manufactured home communities.

Producers of manufactured housing are rarely involved with installation at the site and the HUD-Code does not require monitoring or regulation of installation. HUD-Code producers deliver units directly to independent retail dealers or to dealer-developers that own parks or scattered individual lots. The dealer-developer will usually include the cost of installation as part of a unit's total cost package, and banks include an allowance in the consumer loan to cover installation.

Full-service or turnkey dealers will not only install the unit by providing for anchoring and support, but may also perform site work such as grading, utility connections and landscaping. They can also add ancillary facilities such as garages, porches and decks. Many dealer developers or independent developer/owners who have parks for rent, lease, or ownership already have developed lots for rent or sale that only require connection of utilities once the unit is installed. The HUD-Code does not require any field inspections of installed homes but leaves this up to state and local governments.

HUD HOME INSTALLATION

Most HUD homes are installed on a **dry stack foundation support piers** on **footings** designed to bear the weight of the home. The term dry stack refers **concrete masonry units** (CMU) that are stacked on top of each other in a column without the use of mortar or surface bonding material. Prior to the installation of the CMU foundation support piers, the area around and under the home is cleared of debris and vegetation. The site is also sloped to allow water to drain away from the home. Some manufacturers may require the area under the home to be covered with a non-absorbent material to help assure a dry condition under the home.

Each home should be provided with a **foundation plan** that indicates the foundation support pier and footing requirements and locations. The size and number of support points

varies depending on the soil conditions on the site. If a foundation plan is not available, the home manufacturer should be contacted for a copy. Many local municipalities require the foundation plan as part of the home installation permitting process. Once the area is prepared, the home is positioned on the site by truck or mini tractor.

During the installation process, the home's floor is continuously checked to ensure a level installation. This is typically accomplished with a long carpenter's level placed in several locations in the home or through the use of a water leveling system. As the floor is brought into a level position, the foundation support piers are set and tightened to the supporting I-beam on the chassis and any other locations that has been specified by the home manufacturer.

Foundation support piers are typically supported by concrete footings. The required size of the footing will depend on the soil conditions and the design load specified by the manufacturer. Once the footing location is determined, the footing is formed in a level position. The depth of the footing below the finished grade is determined by local conditions such as the frost line.

Many manufacturers specify 8″ x 8″ x 16″ open or closed cell CMU blocks for the foundation support piers. Depending on the height of the pier the manufacturers may require either a single or double stack configuration.

Due to the natural variation of building sites, the height of the piers will be different and may produce a gap between the last block and the home. Home manufacturers address this issue in several ways. Some manufacturers may specify steel shims to fill the space while others may recommend the use of pressure treated lumber in combination with other dimensional solid concrete units. Regardless of the foundation support pier configuration required by the manufacturer, all piers must be tight fitting to prevent the home from settling, causing a sloping floor.

The **anchoring system** used in Florida consists of vertical ties along the periphery of the home and diagonal ties in alignment with the vertical ties that are connected to the I-beam. Additional anchoring may be required in some cases. If multiple units are being joined together into a single larger unit, a set of centerline anchors must be installed before the second unit is set into position. The locations of all anchors should be identified by the

FIGURE 2.2: PANEL OF A PANELIZED BUILDING BEING INSTALLED BY A CRANE

manufacturer in the installation instructions.

MODULAR HOME LAND DEVELOPMENT

Modular manufacturers, like manufactured housing producers, have typically had little if any involvement in the land development process. Instead, the factories sell to independent or franchised builders, or to home buyers working with a general contractor or builder. In either case the purchaser is responsible for finding an appropriate building lot.

MODULAR HOME INSTALLATION

Modular homes are shipped from the factory to the site in modules and installed on a foundation wall. The first consideration is the site conditions and finding a good location for the crane that will lift the modular units into position. Cranes are expensive and preplanning will help keep the crane operational time to a minimum. The process starts with selecting the proper size crane for both the building weight and the lifting conditions. Another consideration is how the modules need to be staged on the construction site. Without proper planning, time can be wasted relocating both modules and equipment. With proper planning the units can be accessed in the order needed for installation without the need for relocation. Site conditions can be restrictive due to the need for overhead clearance and space for the crane and construction.

In the lifting process the lifting straps are placed below and up both sides of the building, with each end of the strap connected to the crane. The number of straps varies and is based on several factors. Two lifting considerations are the length of the unit and the weak areas of the home due to the floor plan design. The actual number of lifting straps and their locations are specified by the manufacturer's installation instructions. It is extremely important to follow these instructions to avoid both job-site injuries and damage to the unit. Many manufacturers will design additional reinforcement in the area where the lifting straps are located to limit buckling or crushing.

Keeping the unit balanced during lifting is very important. Sometimes the lifting straps may have to be adjusted by a few inches to create a balanced and level lift. It is important to consider any loose items, such as set as **setup-kits** that may have been shipped

FIGURE 2.3: STRAPS AND BELTS ARE USED TO MOVE THE UNIT AND FIT IT ONTO THE RIGHT LOCATION

with the home. These kits can be heavy and may cause the home to become unbalanced during the lifting process.

After lifting, the house is positioned on the foundation so that the home is both square and aligned with the foundation wall. The manufacturer's installation instructions will outline all of the connection requirements between the home and the foundation system. Before installing the second unit, it is important to ensure that all the **close-up materials** between each half have been removed. These materials are provided to protect the modules during shipping and are removed prior to module installation. Once the module has been set onto the foundation, the lifting straps need to be removed. Many times the lifting strap may be trapped between the home and the foundation wall. If this is the case, a hydraulic jack can be used to allow their safe removal.

The application of special sealants and other procedures may be required before the next module is placed on the foundation. Some manufacturers may require a hinged roof to be elevated prior to the installation of the second unit. It is important to follow the installation instructions that have been provided by the manufacturer.

Sealants may be needed between building sections to provide complete closure between the units. Modules may not experience a tight fit during the installation process and there may be a slight gap between the units. These gaps can be filled with an **enclosure material**. Some manufacturers use a gasket material that is installed between the joining perimeters of the modules. Due to the various conditions that may be encountered, a comprehensive checklist is needed to guide the installation. The manufacturer's installation instructions should be consulted to determine both the sealant and joining procedures.

2.1.5 ADVANTAGES AND DISADVANTAGES OF MANUFACTURED CONSTRUCTION

ADVANTAGES OF MANUFACTURED CONSTRUCTION

- Manufactured Construction is time efficient. It can save up to 25% of construction time because fabrication occurs concurrently with foundation and site work, and the production process is less disruptive due to excellent factory work conditions.
- The cost of production can reduce up to 40% initial costs.
- Volume buying power for building materials and appliances.
- Highly trained work force
- Strictly enforced Quality Control Program
- A well-equipped factory setting allows the best construction practices
- In manufactured construction, there are fewer specialty trade contractors.
- Federal requirements and inspection programs are efficient and effective.
- Many design reviews (DAPIA) and inspections (by different personnel, station supervisors, plant quality control department and IPIA inspection agency) produce higher quality
- Low levels of construction waste
- Safe indoor labor conditions

- Environmentally controlled conditions
- Predictable output, mock-up and prototype required
- Ergonomics increased, therefore labor comfort
- Less scaffolding, formwork and shuttering

DISADVANTAGES OF MANUFACTURED CONSTRUCTION

- Financial institutions may require higher interest rates, larger down-payments and shorter term loans.
- Limitations on customizing modular homes in a factory setting
- Negative public perception and image
- There are more plant and site inspections and regulatory requirements for modular units.
- Transit damage potential
- Higher shop overhead costs
- Because of parallel activities, more coordination is required
- Changing the size of major elements is costly
- Less opportunity for skills development
- Full use of workforce, sophisticated machines
- Costly heavy duty cranes for setting modules

A COMPARISON BETWEEN HUD CODE MANUFACTURED AND MODULAR HOUSING

The lower per square foot construction costs for factory-built homes are a result of various factors including lower labor costs, production economies of scale and volume purchasing power.

Manufactured homes also save on construction costs by using less expensive foundation systems and other building products compared to both modular and site-built homes.

Modular homes have higher construction costs than HUD Code homes in spite of the factory production environment because modular homes tend to involve greater customization in the factory because modular factories are typically smaller and cannot achieve the economies of scale compared to those enjoyed by HUD Code producers.

Modular costs reflect some economies of scale compared to site-built production. The extent to which this difference is passed through to consumers as lower prices or retained by producers as higher profits varies greatly.

A COMPARISON BETWEEN MANUFACTURED AND SITE BUILT HOMES

LIFE SPAN OF MANUFACTURED VERSUS SITE-BUILT HOMES

The amount of care and maintenance invested in the manufactured home is no different than any other similar type of construction. One of the main means of providing a longer life span and a healthy house is proper maintenance. In general, wood based construction requires more maintenance than masonry construction.

REGULATIONS

Differences in the regulatory procedures that apply to manufactured homes and conventional housing contribute to differences in the cost of site-built housing compared to manufactured and modular housing. The federal system for regulating manufactured housing appears to be more efficient and less costly to administer than current state and

local systems for regulating site-built and modular construction. Differences in the applicable technical requirements for unit design and construction, while less extensive than the procedural differences, also contribute to the disparity in production costs between conventional site-built housing and manufactured housing.

Site-built housing is generally not subject to the same degree of design review as manufactured or modular housing, nor do site-builders have to adhere to formal programs that demonstrate that the construction process incorporates accepted quality improvement and control procedures. Once designs for manufactured and modular housing are approved, the same or similar designs can be replicated many times in the controlled factory environment where producers can closely monitor labor and schedule the work.

Because the construction details of manufactured housing are subject to internal quality inspections and the units are required to be essentially complete prior to shipment, little remains to be inspected on-site. While manufactured units are theoretically subject to on-site inspections by state and local agencies for installation and utility connections, some building departments are reluctant to become involved with HUD-Code units. Yet more than half of current manufactured housing unit placements involve multi-section homes that must be joined on-site and the installation of other amenities on-site, such as porches and decks is also becoming more common. The degree to which this work is actually regulated is not clear. Modular units probably encounter more site inspection since they are not regulated under the HUD-Code, involve more on-site customization and are usually placed on conventional foundations that are subject to local regulation and inspection.

THE IMAGE OF MANUFACTURED HOUSES VERSUS SITE-BUILT

Many of the obstacles to expanding the market for manufactured housing are related to the undesirable image of manufactured homes, a holdover from the days when these homes were very mobile, very small and placed on very small plots of land in crowded parks. Problems related to lax regulation and the poor quality of site installations of homes that were sold and placed through retailers, have contributed to a negative perception of manufactured homes.

FINANCING

In the case of modular homes, the clients or buyers usually work with contractors who build with modular technology and have the appropriate license to install the house. The builder or contractor works with a bank to provide the future home owner with a package that includes the land, home, installation costs and other items needed to completely acquire and install the home.

In this process the banks pay the manufacturers, and the manufacturer does not begin construction until an agreement to pay is obtained from the finance company. Buyers do not always need financing from a bank or other financial institution. Some buyers make a cash down payment and then pay the balance upon delivery of the unit to the site. After

an order is made, the manufacturer begins the design work, obtains the approval plans, orders the (required) materials and schedules the unit for production.

COMPARING THE COST OF RESIDENTIAL SITE-BUILT CONSTRUCTION AND MANUFACTURED HOMES

The lower per square-foot construction costs for factory-built homes reflect various factors including lower labor costs, economies of scale in production and volume purchasing power. By comparing the site-built home and the comparable manufactured modular construction home with the same material qualities such as same windows, siding, carpet and other components and assuming that the specifications for both have been met, savings can range from 20% to 40%. The major advantage of the manufacturing plant is the ability to produce the home much more rapidly. This allows the builder to complete more projects in a given time frame.

Certain activities increase the required time. Custom manufactured homes may require additional time for plan approval and special materials. Even with these time delays, the home can be completed in a week. This is much faster than the time required to complete the site preparation and permitting process. The contractor and the manufacturer must work very closely in scheduling the installation process.

COMPARISON BETWEEN HUD & MODULAR HOMES

Manufactured homes save on construction costs by utilizing efficient foundation systems and by value buying of building materials. Modular homes have higher construction costs than HUD-Code homes, despite the common factory production environment, because modular homes tend to involve greater customization both in the factory and on-site and because modular factories are typically smaller and cannot achieve economies of scale comparable to those enjoyed by HUD-Code producers.

REVIEW QUESTIONS 10

1. Name the steps in constructing a manufactured house.
2. Who develops land for manufactured housing?
3. Is the manufactured housing producer also responsible for land development?
4. Who is responsible for the installation of modular or HUD houses?
5. Describe how land is made ready for HUD house installation?
6. How is a HUD house installed?
7. How is a modular house installed?
8. What are the advantages of manufactured construction?
9. What are the disadvantages of the manufactured construction?
10. What are some differences between manufactured housing and the site built housing?
11. How does a HUD home differ from a modular home?

2.1.6 WORK ENVIRONMENT FOR FACTORY-BUILT VS. SITE-BUILT HOMES

One big advantage of the factory environment is how materials are stored during the construction of the home. On a site-built construction project, materials are stored uncovered on the job site and are subject to weather damage. The result can be poor quality products and materials being used in the construction process. In contrast, in the factory the materials are protected and the conditions are controlled. On-site, the house is made from outside inward because the first step is to protect the house from unpredictable weather conditions. In the factory, this is reversed and the interior walls are built first so that there are no obstacles to moving large components such as walls into the house.

In the factory, the workers are provided with job specific tools in a weather-protected environment. Most manufacturing facilities have a maintenance support staff and other resources to meet the needs of the production process.

The mechanically lifted scaffolding system or the **gantry** is a great time saving feature on the assembly line. Unlike the need to assemble and disassemble scaffolding which takes place at the on-site project, gantries are always in place and ready for use in the assembly process.

The affordability of factory built housing can be attributed directly to the efficiencies of the factory-building process. The controlled construction environment and assembly-line techniques remove many of the problems encountered during traditional home construction, such as poor weather, theft, vandalism, damage to building products and materials, and unskilled labor. Factory employees are trained and managed more effectively and efficiently than the system of contracted labor employed by the site-built home construction industry.

Building homes in a factory environment also helps reduce the time frame for completion of a custom project. The normal time frame for modular home production is 5-7 months allowing for the process of obtaining financing, permit processing, engineering and production and on site completion. The time savings occur because manufacturing can begin in the factory at the same time the foundation is being built on the site.

Much like other assembly-line operations, modular homes benefit from economies of scale resulting from purchasing large quantities of materials, products and appliances. Modular home builders are able to negotiate substantial savings on many components used in building a home, with these savings passed on directly to the homebuyer.

There are also green (earth friendly) benefits that result from building a home in a factory environment. Prefabrication techniques reduce waste, offer energy-saving designs and improve manufacturing and construction efficiencies. As a result, the conditions in the factory create an atmosphere that supports the workforce in performing their jobs as easily and efficiently as possible.

2.2 PRODUCTION RATE OF MANUFACTURED VS SITE BUILT HOMES

If there are 20 stations in the factory and the line is being moved 5 times a day, a home will be produced in 4 days. Depending upon the size of the plant, there can be up to 150 people working there, each at 8 hours a day. Because of the process flow and the differentiated production tasks, the work is done much faster than in site-built construction. For site-built construction, a very simple home may take 3 months and a complicated home from 6 months to a year or more to complete. The production rate in the factory is much higher and more efficient than for on-site construction.

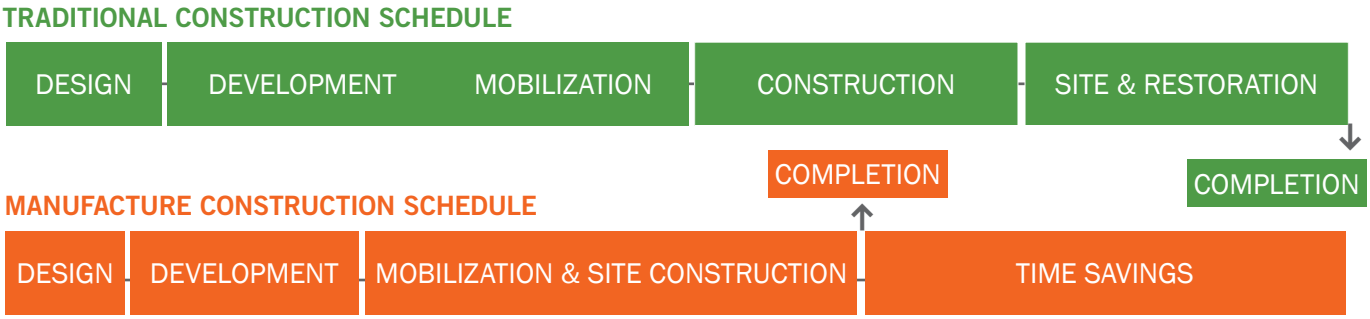

FIGURE 2.4: THERE IS CONSIDERABLE TIME SAVINGS FOR MANUFACTURED CONSTRUCTION COMPARED TO SITE-BUILT CONSTRUCTION

REVIEW QUESTIONS 11

1. What are the advantages of construction in a factory environment?
2. How is the timing in manufactured construction different than for site built homes?
3. Name a few green (earth friendly) features of manufactured construction that are a result of the factory setting.
4. In how many days can a manufactured house be produced?
5. What strategy helps create the time savings in the manufactured construction process?

2.3 TOOLS SPECIFIC TO MANUFACTURED CONSTRUCTION

2.3.1 JIGS

A **jig** is a type of custom-made tool used to control the location and/or motion of another tool. The jig's primary purpose is to provide repeatability, accuracy and interchangeability in the manufacturing of products. Jigs are needed in factory settings to increase the speed and accuracy of production. Jigs or templates were known long before the industrial age. There are many types of jigs and each one is custom-tailored to do a specific job. Some jigs are made to increase productivity through consistency, to do repetitive activities, or to do a job more precisely. Jigs can be made for frequent use and can be improvised from scrap for a single project, depending on the task. Some jigs are also called **templates** or **guides**.Jigs are also described in Section 3.2.

2.3.2 PNEUMATIC AND ELECTRIC TOOLS

A **pneumatic tool**, sometimes referred to as an air tool, air-powered tool, or pneumatic-powered tool is a type of power tool driven by compressed air supplied by an air compressor. Pneumatic tools can also be driven by compressed carbon dioxide (CO_2) stored in small cylinders, allowing for portability. Pneumatic tools are safer to run and maintain than their electric power tool equivalents, and they have a higher power-to-weight ratio, allowing a smaller, lighter tool to accomplish the same task. General grade pneumatic tools with short life spans are cheaper and also called **disposable tools** by the tooling industry while industrial grade pneumatic tools with long life span are more expensive. In general, pneumatic tools are cheaper than the equivalent electric-powered tools.

Pneumatic tools used in a manufactured construction factory include nail guns, staple guns, screw driver and others.

2.3.3 GANTRY

A **gantry** is a structure used to straddle an object or work space. Gantries in manufactured construction are like fixed bridges and they can be mechanically raised and lowered. Some gantries are on wheels and are rolled into position and out of the way during line movement. Some can move upwards and rise to the desired working height for the unit in production.

FIGURE 2.5: JIGS ARE USED TO BUILD LEVELED, SQUARED AND PRECISE FLOORS AND WALLS

FIGURE 2.6: USE OF PNEUMATIC TOOLS IN THE FACTORY

FIGURE 2.7: GANTRIES CAN BE ADJUSTABLE OR FIXED BRIDGESTORY

FIGURE 2.8: GANTRIES OPERATE BASED ON THE MOVEMENT OF THE UNITSTORY

REVIEW QUESTIONS 12

1. Describe the work flow in the lay-out of manufactured construction factory.
2. What is the function of a jig in the factory?
3. Explain how a pneumatic tool operates.
4. What is the difference between scaffolding on a construction site and a gantry in a manufactured construction factory?

FIGURE 2.9: USE OF GANTRIES IN THE FACTORY

2.3.4 CHASSIS

The **chassis** is a steel frame that supports and carries the house to its destination. During the production of the steel chassis that will carry the weight of the home, the I-beams in the chassis are deliberately bent or distorted to produce a higher area between the front (hitch end) of the home and the axles. A second high area is produced at the end of the home. The natural weight of the home will cause the high point to lower and ultimately produce a level floor and home upon completion. This intentional distortion of the chassis is referred to as **camber**. The camber is created by applying heat in specific areas of the chassis.

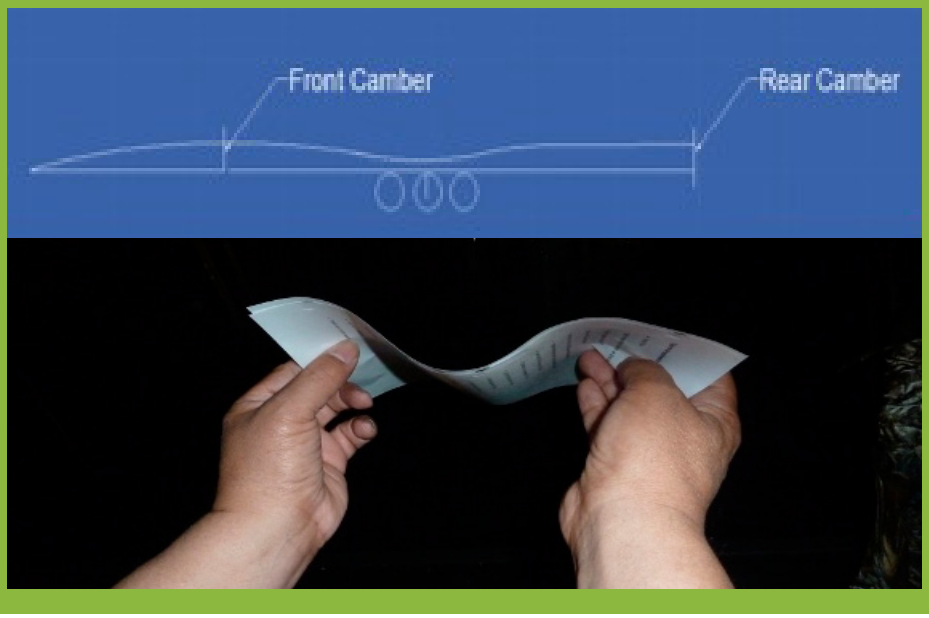

FIGURE 2.10: A LOADED CHASSIS WOULD EVENTUALLY BEND IN AN S-SHAPE DUE TO THE NATURE OF STEEL

FIGURE 2.11: A TYPICAL CHASSIS READY TO BE PAIRED WITH THE UNIT FLOORING

FIGURE 2.12: A CHASSIS AND ITS HUD UNIT

FIGURE 2.13: TRANSPORTING A MODULAR HOME FOR INSTALLATION

For HUD houses, the chassis (see figure 38 above) stays with the house and, by law, the chassis cannot be removed from a HUD house. HUD homes are designed and built for different wind zones, for example, Wind Zones 1, 2 and 3. Wind Zones 2 and 3 require vertical and diagonal ties.

For modular houses, the chassis usually comes back to the factory. For this reason, it is built with heavier I-beams and is therefore more durable to allow repeated usage. However, if the chassis is part of the design of the house, it will stay on-site with the house. Compared to the single-use chassis used for HUD or manufactured homes, the chassis for modular homes is made for repeated use with varying sizes and weights of homes. For a modular home, if there is a concrete foundation wall, the foundation wall is bolted to the foundation plate which is attached to the home. The home manufacturer provides the details and specifications needed to perform the installation and it is extremely important to these instructions.

REVIEW QUESTIONS 13

1. What is a chassis and what is it used for?
2. Why is it needed for the chassis to be cambered?
3. What is the difference between the chassis made for HUD homes and for modular homes?

MODULE 3

THE PRODUCTION ENVIRONMENT

The production processes that are followed in each manufacturing facility can vary significantly. Each plant is designed to meet the specific needs of the products being built. Some basic construction considerations are the width and length of building, the wall height, the roof slope and other possible variations.

During the plant design the types of product being offered must be considered. Each work station is designed to accommodate the **floor** for a single HUD home or the floor for one of the sections of a modular home. The number of floors completed at each station per day controls the design of the plant and the number of employees needed.

Within the manufactured housing plants, there are a wide variety of sizes and configurations. Some plants are considered to be small plants with 10 or fewer production stations. Other plants can have in excess of 20 stations and are considered large production plants. Though the number of employees who staff a plant can change significantly based on production rate and the blend of product offerings, an average plant will be staffed with approximately 34 production workers per floor produced per 8 hour shift. For a plant containing 10 stations with an average blend of product offerings and building 3 floors a day, approximately 102 production workers would be needed.

Adding production workers is not always the solution to increase production. If the initial design of a plant has an inadequate number of stations, the addition of workers can create an inefficiency in station output and result in no increase in production output. Designing and managing the products entering the plans and managing the product output is a skillful art.

3.1 PLANT LAYOUT AND RESPONSIBILITIES

3.1.1 PLANT LAYOUT

The production process is divided into different departments that contain one or more stations where a stage of production is taking place. In some plants there may be an overlap of different tasks or activities, but typically each department is responsible for a set of specific tasks. Here, we use an example of a plant which consists of 10 stations staffed with 85 people.

MAIN PRODUCTION LINE

On the **Main Production Line**, units start at one end of the assembly line and move to the other end to eventually become a complete unit. The Main Production Line consists of stations. For example, the floor units are built on a steel frame called a **chassis** and are assembled in an upside-down position. After the floor framing, basic electrical, plumbing, insulation, boarding, and decking are completed, the frame and the chassis are flipped such that the floor surface is now pointed at the plant ceiling. In this position the tub or shower enclosure is installed, and the floor is checked by the workers and inspected by the supervisor of that section. The floor framing is now complete and ready to be pulled to the next station, the wall assembly station. At this station, the walls, including the interior walls, the exterior walls or siding and the **marriage walls** are assembled.

Marriage wall is a load bearing wall located between modules of a prefab house and does not require insulation. There is only one marriage wall in a double wide modular home.

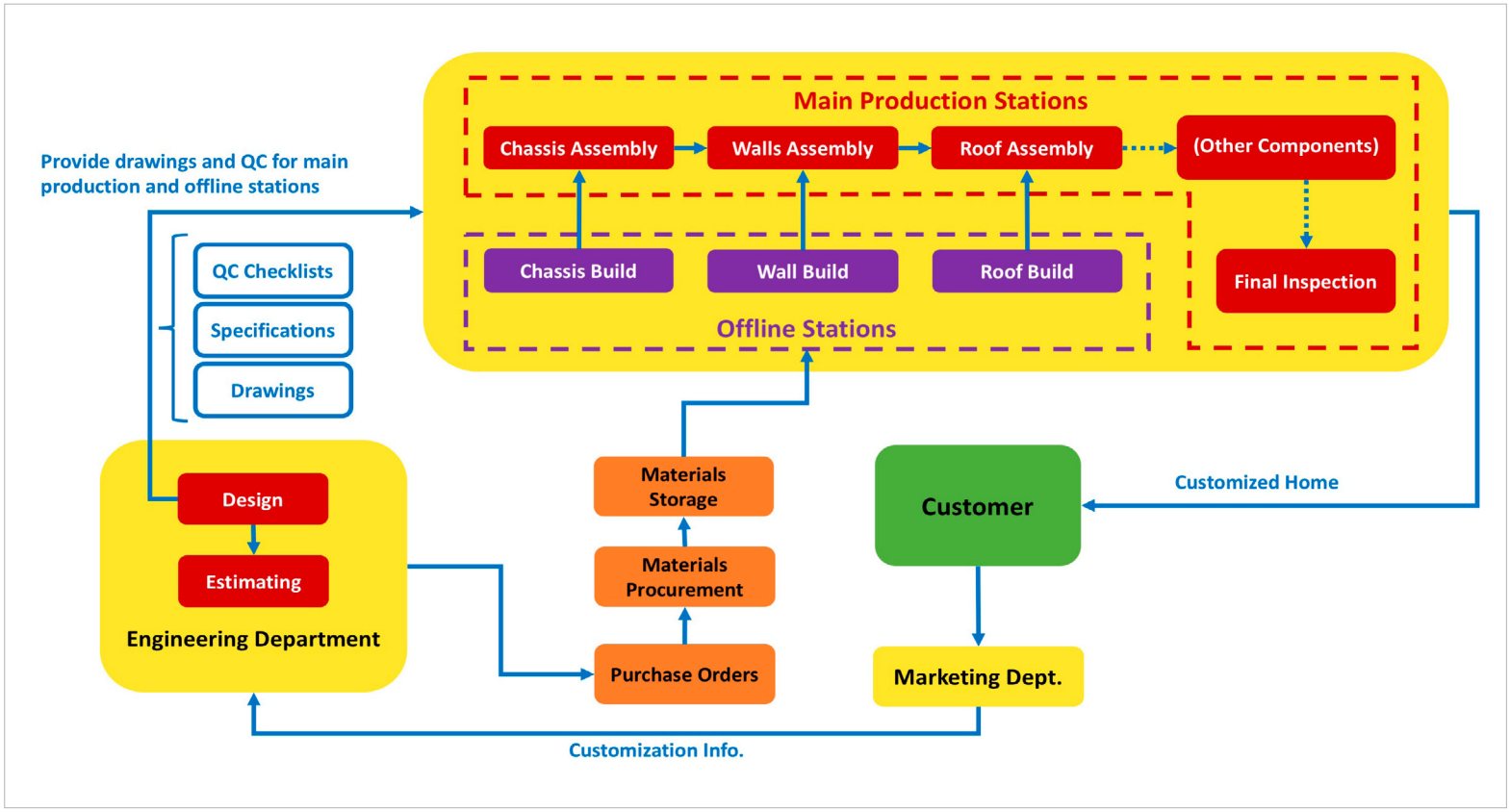

FIGURE 3.1: AN OVERVIEW OF THE PRODUCTION LINE

FIGURE 3.2: VIEW OF THE MAIN PRODUCTION LINE IN A MANUFACTURED CONSTRUCTION FACTORY

OFF-LINE STATIONS

Off to the side of the Main Production Line are **Off-Line Stations** where major components are assembled. Off-line stations do not travel and are fixed in place. At these stations, components such as walls, roofing and millwork are built. The products of these stations feed the Main Production line. If one thinks of the Main Production Line as the central activity, there are off-line stations on the sides of the Main Production Line that feed the main Production Line. These peripheral activities and spaces include cabinet shops, the millwork shop, a welding station for building the chassis, wall and truss stations, and storage for adhesives or other materials. Depending on the location of the unit on the assembly track, the appropriate stations feed the Main Production Line.

FRAME AND FLOOR DEPARTMENT

A typical Frame and Floor Department contains multiple stations, for example, four Main Line Production stations, where the wood floor system is framed in an inverted position, insulated and equipped with floor plumbing, water distribution and electrical wiring. The frame is attached to the floor system and the floor is rotated into and the floor decking is installed. The floor decking is then sanded and made ready for the floor finish material.

FIGURE 3.3: FLOORING IS ALMOST READY IN THE FLOORING STATION

WALL BUILD AND WALL SET DEPARTMENT

The **Wall Build and Wall Set Department** can contain one or more stations of the production process. The Wall-Build and Wall-Set Department usually consist of one production station and five off-line support stations. In this department, the interior partition walls, marriage-wall, and side and end walls are built. This area consists of several tables specially designed for the construction of the various types and sizes of walls needed for the homes under construction. As the walls are built, they are placed into production **transition racks**, awaiting the wall set installation personnel.

The wall set personnel are required to determine the locations where the various walls are to be installed on the floor traveling along the production line. Once the wall location is identified, a logical order for setting the walls will begin. The order in which the walls are set is often dependent on the floor plan and production restrictions. The bathtubs and shower units are often positioned on the floor prior to the installation of the bathroom walls. This provides adequate space for the placement of the large construction components.

FIGURE 3.4: WALLS BEING COMPLETED IN THE OFFLINE WALL STATIONS

FIGURE 3.5: INTERIOR WALLS ARE BUILT IN THE WALL ASSEMBLY STATION

ROOF BUILD AND ROOF SET DEPARTMENT

The **Roof Build and the Roof Set Department** normally consists of two offline stations and one production station. The first offline station consists of a roof build table where the ceiling gypsum sheets are placed on the table followed by the placement of the roof trusses. The ceiling material is attached to the roof assembly using a two-part adhesive that is sprayed along the gypsum and the bottom chord of the truss. All components related to the roof construction, such as ridge-beams, are completed at this point. Electrical wiring is placed in the roof system as required by the floor plan. In addition, at this time any ceiling ductwork and insulation will be installed. Once all the components of the roof system are completed, the roof assembly is transferred to a second off-line station. In this station, work on the ceiling system begins. All

ceiling prep work is performed within this area. Once the ceiling prep work is completed the ceiling finish material is applied. Upon the completion of the ceiling finish, the roof assembly moves into the production line and is placed on the previous floor where the walls were recently installed.

In the roof setting process, the connection between the roof and wall elements are checked to make sure they are square and in alignment. Finally, the required connections between the assemblies are made and any components that extend through the roof system are prepared.

FIGURE 3.6: TRUSSES BEING ASSEMBLED ON THE ROOFING STATION

FIGURE 3.7: SHINGLES ARE READY IN THE ASSEMBLY ROOFING STATION

ROOF FINISH / INTERIOR WORK IN PROCESS

The **Roof Finish Department** is usually a Main Production Line station and it may have multiple stations. In this area of the plant, the roof decking is installed along with any penetrating devices, the soffit and fascia, windows, doors, exterior trim and exterior siding. In this area, the interior finish, cabinets and interior electrical work are completed along with the plumbing.

FINISH DEPARTMENT

The **Finish Department** may have several stations and extend outside of the building into the yard area. Many different activities are conducted in the finish department during the completion of the exterior of the home in the previous station. Inside the home, many of the tasks that were started a station or two back in the Main Production Line are now being completed. New activities such as finish plumbing, finish electrical work and interior trim are underway. The start of the cleanup begins and window treatments are installed. Any rework that has been identified should be nearing completion.

The home testing is also completed at this station and consists of tests of the electrical, plumbing, water, drain and gas systems. Final quality control inspections are conducted, along with final clean-up. Any products that are needed for installation are placed into the home and the appropriate Insignia is affixed. The home is now ready for shipment.

FIGURE 3.8: TRIM-WORK AND FINAL FINISHING IN THE INTERIOR OF THE UNIT

FIGURE 3.9: SOFFITS AND TRIM-WORK ON THE EXTERIOR OF THE UNIT BEING INSTALLED

REVIEW QUESTIONS 14

1. Describe what the "floor" terminology means. How does it define the size of a plant?
2. What is the difference between the main production line and the off-line production line?
3. Explain the first four stations in the framing and flooring department.
4. In wall department, how many possible stations could exist, and what are the functions of each station.
5. What is the first off-line station in the roofing department? Name a list of the building completion covered in this station.
6. How many possible teams can work in the finishing department simultaneously?

OFF-LINE CABINET SHOP

The **Cabinet Shop** is usually an off-line production station and the finished cabinets from this station are delivered to the production line for installation. The cabinet shop typically carries out the construction and assembly of the doors, drawer units and counter tops. The actual installation of the cabinets is usually handled by a cabinet installation crew when the building is in the roof finish department.

SUPPORT DEPARTMENTS

The support departments consist of off-production operations that are essential during the manufacturing construction process. These departments are composed of maintenance and administrative staff.

TRAVELER

Each floor traveling along the Main Production Line has a listing of the detailed tasks at each of the stations. This task listing accompanies the floor and indicates the sequencing

of both the Main Production Line stations and the off-line and sub-assembly stations. A document known as a **Traveler** moves along with the floor through the various stations and as the assigned tasks are completed, the Traveler paperwork is completed. On the Traveler, a brief listing or description of the work is shown and is signed off by plant authorized staff upon successful inspection.

REVIEW QUESTIONS 15

1. What is the function of an off-line cabinet shop?
2. What is the sequence of a typical production line?
3. What is the difference between standard drawings and custom drawings?
4. Who is the approving third party agency?
5. What part of a drawing is called the specification, and what is its function?
6. Which type of homes are attached to chassis and will stay on chassis for the rest of their life? Why?

Quality Traveler

Item	SAT	UNS	Item	SAT	UNS	Item	SAT	UNS
Station 7B			**Station 9**			**Sattion 11**		
ROOF BUID			ROOD SET/Insulation			EXTERIOR		
Trusses			Ceiling connection			Exterior sheathing		
Framming and Blocking			Rought Wiring			Windows/ doors		
Celing board			Up lift straps			Electrical		
Vapor Barrier			Roof insulation			Exterior siding		
Rough Wiring			Back panels			Roof underlayment		
HVAC System			Fixture			Roof decking/ insulation.		
Station 8			**Station 10**			**Station 12**		
ROOF SET			ROOF DECK			EXTERIOR		
Ceiling Connection			Roof insulation			Exterior siding		
Rough Wiring			Roof decking			Windows/door		
Up lift straps			Electrical			Electrical		
Back panels			Dormer			Shingles/ Metal Roof		
Fixtures			Extrerion sheathing			Dormer / set		
Approval:			Champion Homes Builders, Inc. Plant #261-A 1915 SE State Rd. 100 Lake City, Florida 32025 Quality Assurance Rev. Date:					

3.10: SAMPLE TRAVELER FORM

3.1.2 PRODUCTION SEQUENCE

CUSTOMER ORDER

Most manufacturers sell their products through a network of independent retail sales centers. The independent sales centers are the first line of contact with the customer. Once the order is taken it is given to the manufacturer as a production order. The required drawings are assembled for approval and to guide the home production.

STANDARD DRAWING OR CUSTOM MADE DRAWING

Most manufactured home companies have a standard product offering, which usually changes each year. Changes can be made to floor plans, interior décor such as floor coverings, colors, exterior finishes and options that will be offered for the production year.

If a client selects a floor plan from the standard production offering, special approval is usually not necessary. However, if a custom floor plan design is requested or extensive variations to an approved plan are desired, this would trigger a need for additional approvals prior to the manufacturing of the building.

APPROVAL FROM THIRD PARTY AGENCIES

Each manufacturer who builds under the HUD-Code program must select a DAPIA to review their plan submittal. The DAPIA is tasked with the responsibility to either approve or disapprove the request. Ultimately, they are responsible for ensuring the plans are in compliance with the HUD-Code.

A building constructed in the modular program has much the same requirements. However, instead of using a DAPIA for review, an independent third party review agency is selected for this purpose.

CONSTRUCTION DRAWINGS

A **construction package** is a set of drawings that provides adequate information for building the desired structure in full compliance with all codes and specifications.

MATERIALS ORDER

In most cases the needed materials are ordered by a plant purchasing agent. The required materials to construct the building are determined by the plans and **specifications**. It is extremely important that the proper materials be ordered so that the end product, the home, has all the products and materials needed for its assembly. For example, a window used in one wall of the home may be different than another window several feet away on the same wall. For this reason, Specifications, which thoroughly describe the materials, methods and execution of the assembly process are required for each home being built.

BUILDING OR ORDERING THE CHASSIS

A HUD-Code home must remain on the chassis throughout its life. The structural systems are designed with the support being supplied by the chassis and its removal would bring the building out of compliance.

In the case of a modular product the building may be designed for an on- or off-chassis system. It is important to understand that if the chassis is designed as an integral part of the floor system, it must remain installed with the building.

3.1.3 PERSONNEL AND THEIR RESPONSIBILITIES

The following organization chart shows the relationships between people within a manufacturing plant. Responsibilities for each person are described on the following page.

The **General Manager** is responsible for:

- The overall quality of the products and services.
- Ensuring all designees (a person or persons who are assigned the responsibility to perform an action within the operation) are fulfilling the requirements of the Manufacturer's Quality Manual.

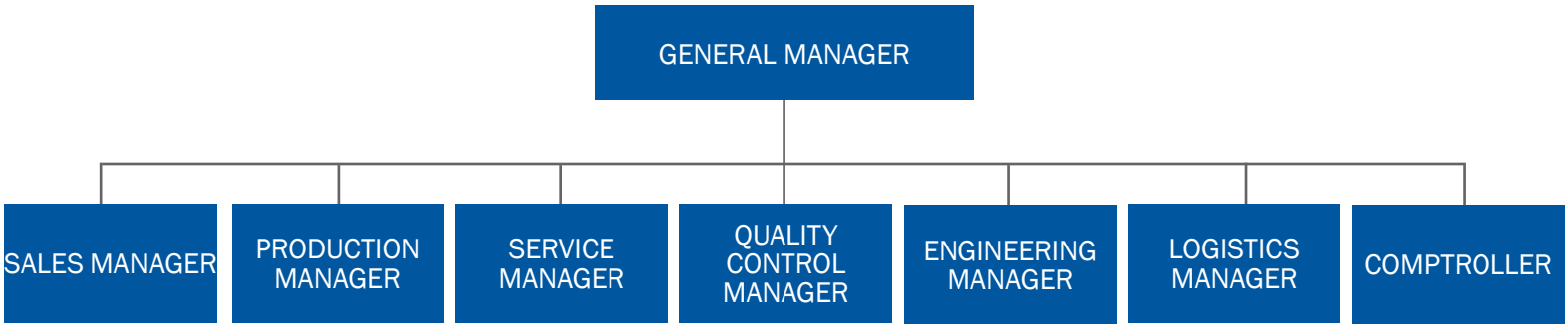

FIGURE 3.11: ORGANIZATIONAL CHART FOR A MANUFACTURED CONSTRUCTION PLANT

The **Production Manager** is responsible for:

- Providing a quality product built to code and customer requirements. Ensuring that the Traveler and related documents are attached to the home or available in or on each section of home or building and that it is being properly utilized.
- Maintaining an up-to-date list of **Accountable Employees** (see definition below) who are authorized to initial or sign off the Traveler package and/or related documents.
- Reviewing Quality information from available sources including **Traveler Deviations**. (A deviation in the traveler is what is noted on the traveler; during the plant quality inspection, when a nonconformance is identified; the observation is documented on the home's paperwork traveling with it on the production line), final inspections, IPIA (Inspection Primary Inspection Agencies) findings, IBTS (The Institute for Building Technology and Safety) audits, warranty claims, and other information sources and initiate corrective actions to identified failures to conform as appropriate.

Supervisors are responsible for:

- The work that their hourly associates perform, and for holding them accountable for the quality of their work.
- Training their associates to properly perform their work functions.
- Inspecting the work for compliance, reviewing prints for accuracy and ensuring high standards of workmanship.
- Supervisors are Accountable Employees.

Accountable Employees are responsible for:

- Knowing the requirements for their area of responsibility.
- Compliance with the requirements of their area of responsibility by signing or initialing the Traveler and/or related documents as complete or deviating from the plans and specifications.
- Providing training and guidance as necessary in their area of responsibility.
- The Quality Manager is responsible for:
- Ensuring DAPIA and/or design packages used are current.
- The Traveler including sub-assemblies and/or off-line, Work Processes, Station Flow Diagram and any related documents are current and approved by DAPIA and/or State, if necessary.
- The Traveler and related documents are being used correctly.
- Working with the Production Manager on a consistent basis to address and communicate quality issues. The Quality Manager has the authority to "stop the line" if necessary to prevent non-conforming product. Only the Quality Manager or General Manager can release the line if stopped.
- The training program is being utilized correctly, is efficient, effective and is being documented. If results do not meet requirements, then Quality Manager should initiate action to be taken including, but not limited to retraining, reassessing, additional training materials, root cause analysis and/or Plans of Corrective Action. (The Plan of Action is used to correct existing defect and prevent future occurrence of a noncompliance.)
- Conducting and documenting spot audits of materials for compliance (document by log or electronic).
- To be the management representative responsible for reviewing the performance of the Quality Systems, liaison with external agencies, reporting on quality performance and working with others on matters relating to quality.

Inspectors are responsible for:

- Inspecting conformance to Quality System requirements.
- Inspectors, who are Accountable Employees (the person or persons who are responsible to perform a duty) must be knowledgeable in their areas of responsibility.
- Inspectors are Accountable Employees.

The **Engineering Manager** is responsible for:

- Ensuring that designs comply with the applicable requirements.
- Providing complete and accurate engineering drawings.
- Knowledgeable of DAPIA and/or State requirements.

The **Purchasing Manager** is responsible for:

- Accurate receiving documentation for the correct building materials.
- Compliance to receiving procedures.
- Maintaining complete, accurate and up to date manufacturers' installation instructions.
- Informing the Quality Manager of any changes to materials.
- Training of receivers for confirming product identification, count and any required receiving inspections.

- Ordering materials that conform to standards, codes and engineering requirements.
- Proper storage of materials.
- Tagging and removal of any products that have been determined to not comply with the standards, codes, or otherwise should not be used in the manufacturing process.

Receivers, reporting to the Purchasing Manager, are responsible for:

- Being knowledgeable of and following all receiving procedures for all materials and products.

The **Sales Manager** is responsible for:

- Ensuring that the sales orders and change orders contain accurate information and are communicated to the Production Manager.

The **Service Manager** is responsible for:

- Providing timely and effective **service to homes** (This term is used in respect to warranty-related work performed on the home.)
- Identifying production issues and providing timely and effective feedback to the Production Manager.
- Providing documentation as required by the Standards.

REVIEW QUESTIONS 16

1. What does it mean to be an Accountable Employee, and who could possibly be one?
2. What is the Quality Manager's responsibilities?
3. Describe what a Traveler's deviation means.
4. Service manager provides timely and effective service to homes. What is service to home referring to?
5. What is the function of a Production Manager in the manufactured construction plant?

3.2 USE OF JIGS AND TEMPLATES FOR SPEED AND ACCURACY

Jigs and **templates** are commonly used during the manufacturing process. In some stations, they are fixed tables with key dimensions indicated to facilitate placing framing members in exactly the right position without having to physically measure each dimension. This also eases the placement of electrical and plumbing fixtures.

Generally, jigs are used to simplify regularly repeated tasks to save time. This could be as simple as a precut piece of wood that can be used in place of repeatedly making the same measurement. Another application of a template is the use of a template to speed the installation of an electrical box cutout in a wall panel. In this process, a cutout in a piece of plywood that replicates the cutout pattern saves the worker time by not having to make several measurements for each cutout.

REVIEW QUESTIONS 17

1. How do jigs and templates facilitate speed and accuracy in building the components of a manufactured house?
2. Provide an example where a jig could be used.

FIGURE 3.12: TABLES OR JIGS ARE USED TO BUILD THE FORMWORK

3.3 PRODUCTION DEMAND AND EXPECTATIONS

TIMING

It is essential to understand that manufactured plant activities have to take place in a specific sequence with specific timing. It is crucial that each task be performed within the allocated time because the unit in the previous station will soon be catching up, and will have to occupy the station. If a unit is not ready, the production line stops moving. For this reason, all of the functions within a plant are interrelated and the performance of one job depends on the previous task.

The production line cannot afford an opening or a gap. For example, a completed floor cannot proceed to the next station if the walls are not properly installed. The path and the duration that the units take are critical. It is important to understand that everything in the production line is time sensitive. This means that, if for example, a line moves 8 times in an 8 hour day, every unit has just one hour of time at each station. The employee must understand that the production takes place with specific timing. If the assigned time is exceeded at one station, the other units and all the other employees working on these units will have to wait. To prevent a system collapse, the problem that may be delaying the production process must be addressed immediately.

CREW SIZE

The number of people working in a manufactured construction plant depends on the number of floors to be produced in a day and the size of the plant. Some plants may have the ability to adjust the plant's production by shifting staffing and still maintain the needed efficiencies. The ability to quickly respond to market conditions gives these manufacturers an advantage when the demand for homes fluctuates.

REVIEW QUESTIONS 18

1. Why is timing so important in the process of producing the manufactured house?
2. How does one slow station affect all other stations in the factory?
3. What defines the size of a plant?

3.4 WORK-FLOW

The critical issue for the production environment is to determine how many people are needed in each different area or station so that timing is maintained. The reason is that there are people both on the Main Production Line and at the Off-line stations, all involved in the construction process and directly related to each other. The workers in the off-line stations must complete their tasks on time so that their assemblies are complete and ready for installation as the unit approaches the station. These workers have to build the components on time so that as soon as the floor is ready, the off-line components will be ready. The ideal situation is not to build components ahead of or behind time, but on time. The hoped for outcome is a balanced and properly timed production process.

In Manufactured Construction workflow, there are a lot of issues with the timing and sequencing of workers. This is one of the significant differences between Manufactured Construction and site-built construction. In site-built construction, the individual production rate is not as crucial as for Manufactured Construction because the work flow moves on a room by room basis whereas in the factory several components are built at the same time. The difficult task is to manage people to obtain the desired output, and be able to plug in extra workers when needed. For this reason, most plants have multi-skilled personnel who

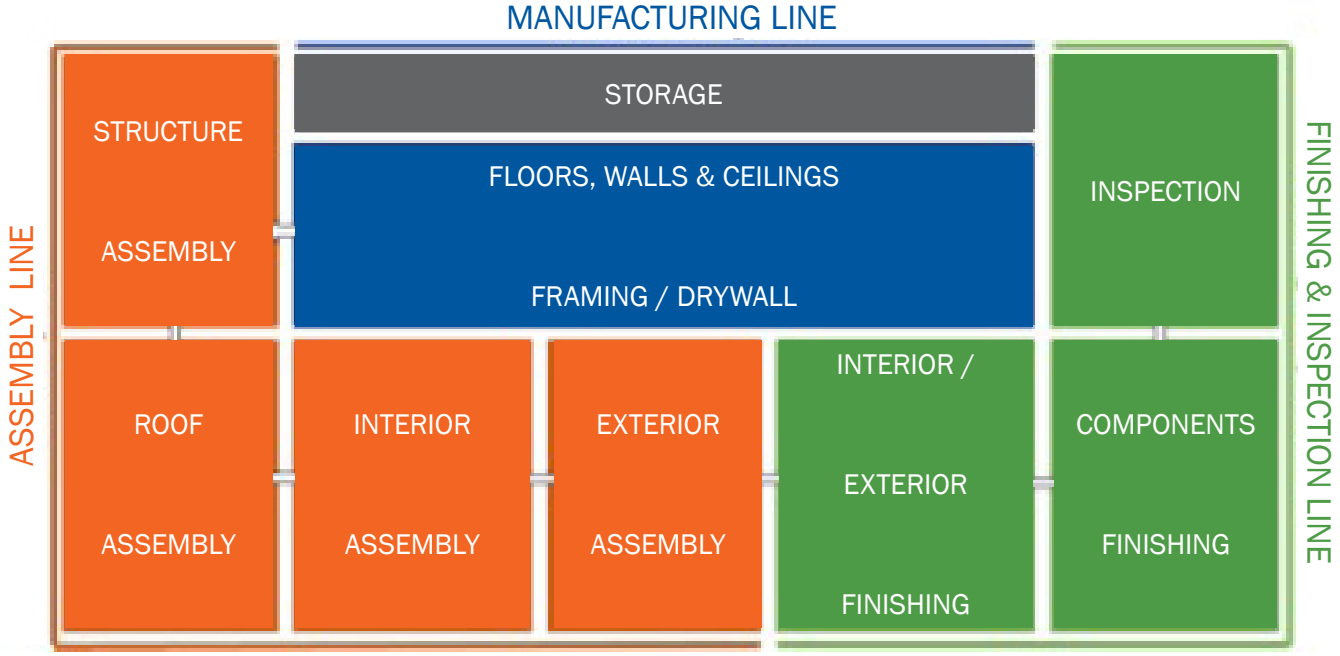

FIGURE 3.13: DIFFERENTIATED TASK ZONES IN THE MANUFACTURED CONSTRUCTION PLANT

are referred to as **floaters**. Floaters are the people who are not assigned to one task area but are relocated to various stations in the production line.

In the plant environment, each station completes a set of assigned tasks. The sum of these tasks ultimately produces the finished building. Much like a puzzle, each piece must fit with the other and any variations from the plans and specifications can impede the next stage of production, resulting in disruption to the production process. This disruption can be extremely expensive because workers are not being productive when they are waiting for the building to progress along the production line.

REVIEW QUESTIONS 19

1. How different is manufactured housing and site built housing in terms of exact timing and work-flow?
2. Describe why managing people in the manufactured construction plant is difficult.
3. Who are floaters in the planning of work force distribution in a plant?
4. Explain why it could be very costly if a station runs slow, and the employees wait for specific completion performed in the previous sections.
5. What is the difference between assembly lines and the workshops in the factory?

3.5 DESIGN PACKAGE

The set of plans that are developed for the construction of the building is typically called the **design package**.

In addition to the plans, a set of drawings that may be registered as **typical drawings** can be considered part of the design package. This set of plans and specifications will control the construction process of the building.

3.6 SAFETY CONSIDERATIONS FOR FACTORY PRODUCTION

In a factory, heavy walls and roofs are being lifted in addition to heavy floors rotating and moving overhead. These types of activities create safety and hazard considerations. Employees must be aware of the dangers involved in these circumstances and safely and properly use the required tools to perform their tasks. There is constant movement occurring on the plant floor. Objects may strike workers and cause injury if insufficient attention is paid to the activities that take place in this environment. The movements may be around or above the workers, therefore everyone has to be aware of the dangers associated with the tasks and the movement of objects in and near their space.

Generally, as is the case with any job site, there are numerous hazards that can affect the workers. In a Manufactured Construction plant, there are some conditions that are not found on a typical construction site. These include the lifting of large components during the construction process. Wall assemblies, roof assemblies and floor assemblies are examples of large, heavy components constantly being lifted overhead in a Manufactured Construc-

FIGURE 3.14: A CHASSIS AND ITS FLOORING IS FLIPPED TO ITS FINAL POSITION IN THE FLOORING STATION

FIGURE 3.15: SAFETY BELTS ARE USED WHEN PERSONNEL WORK AT HIGHER LEVELS

FIGURE 3.16: OBJECTS BEING MOVED IN THE PLANT

tion plant. The lifting and movement of these large components onto the production line can present significant hazards to the workers. It is important to always be observant when in the plant. Because production is a constant process, these and other hazardous conditions are occurring constantly throughout the day. Another situation that the production worker must always be aware of is the movement of the production line. In some cases the line is moved by a chain drive system. Anyone caught in the path of travel of these units can find themselves being seriously injured.

REVIEW QUESTIONS 20

1. In the construction of the building process, what is the function of the design package?
2. What are the possible dangers involved in working in the manufactured construction factory?
3. Why do you think working in the main production line of the factory could be dangerous? What situations could possibly trigger accidents?

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OTHER USEFUL WEBSITES

FLORIDA READY TO WORK:
http://www.fdareadytowork.com

INTERNATIONAL CODE COUNCIL, 2010 FLORIDA BUILDING CODE RESIDENTIAL:
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MODULAR BUILDING INSTITUTE:
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MODULAR HOME BUILDERS ASSOCIATION OF MAINE (MHBA):
http://www.modularhomebuilders.org/modular-design

NATIONAL CENTER FOR CONSTRUCTION EDUCATION AND RESEARCH (NCCER):
http://www.nccer.org

WHY BUILD MODULAR?
http://www.modular.org/HtmlPage.aspx?name=why_modular

WHY MANUFACTURED HOMES? MA WILLIAMS MANUFACTURED HOMES:
http://www.mawilliamshomes.com/whymanufactured.aspx

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NOTES

INTRODUCTION TO MANUFACTURED CONSTRUCTION

FOURTH STUDENT EDITION

Miami Dade College

UF UNIVERSITY of FLORIDA

SF SANTA FE COLLEGE

POLK STATE COLLEGE

Colorado State University

SEMINOLE STATE COLLEGE OF FLORIDA

UNIVERSITY OF WISCONSIN STOUT
WISCONSIN'S POLYTECHNIC UNIVERSITY