A Study on Application of Site Work Simulation System for Civil Construction Planning Using Object Oriented Three-Dimensional CAD/CAM System

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A B S T R U C T

Civil Design Project vary in complexity in recent years. Big Civil Project have been already started for 21st century. It is possible to design structures, which have been difficult to design before, using some high-technology computer methods, e.g., FEM Analysis System, CAD/CAM system, etc. We are sometimes able to recognize that some of their designs are hard to construct them in the actual construction sites, even if it is possible to design them by calculations on the desk. It is particularly difficult to construct in an Urban Construction Site because of their physical land space issues and obstacles issues. At present, the precision of construction is depended on the actual civil engineer's experiences. Especially, Plant or Mechanical & Electrial Facility Planning are depended on them.

This study provides an efficient way of the Site Location Planning using a New Three-Dimensional CAD/CAM methods which is showed as follows.

1. INTRODUCTION

CAD/CAM System for Civil Engineering have spread for the present ten years in Japan. We have used them in order to design civil structures, and have developed Convenient Turn-Key System, Two-Dimensional Drafing System for reinforcing steel drawings, Road Design System, and Golf Course Design System, etc.

Most of these systems might be for creating some geometric shapes and pretty drawings. Though it is a very significant way make the effective drawings, we also need to consider the actual site location plannings whether the civil design is really able to construct or not using some CAD/CAM methods.

2. TREND OF THREE-DIMENSIONAL CAD/CAM SYSTEM FOR CIVIL DESIGN

2.1 Visualizaion Using CAD/CAM System

In recent years, CAD/CAM System for Civil Design have spread in the Civil Industry as Visualizaion System, e.g., Computer Graphics System for Landscape Simulation, More Realistic Rendering System to represent actual civil structures, etc. Like these methods have already been acknowledged as an effective CAD/CAM tool for Civil Design. Nowadays, we can never design without the CAD/CAM tools.

2.2 Posing a Problem on Visualization Using CAD/CAM System

We civil engineers are already recognizing that Visualization System is indispensable to Civil Design. On the other hand, however, we also have recognized that Civil Design have to be taken considration how civil structures are constructed in the actual construction site. In short, it is an important business for civil engineers of construction companies to consider a best construction method to build an actual structures.

This study poses a problem that Civil Design using CAD/CAM System is not only for Visualizaion but also for Site Simulation System which sould be considered a best way in order to construct actual civil structures.

For example, the following are typical issues for civil engineers, when they construct actual structures on construction sites.

- Though civil structures have been bigger from year to year by use of high-technology methods, can we actually construct them without a problem in the site work, even if it is no problem on the Design?
- Which is a best price as construction method, an A Method and a B Method? We need to consider construction prices based on technical proofs.
- It is essential to an Urban Construction Site to consider the Interfarence Checking between existing structures/ facilities and under construction structures/facilinties. Can we examine them using Three-Dimensional CAD/CAM System in advance?

These investigations as above have been executed since Modern Civil Design Method were started. However, these are still depended on "Hadiwork" by engineer's experiences, though today CAD/CAM system has been spreaded in Civil Industries. We need to establish a way to resolve the issues using a significant way by some high technology methods.

3.DEFINITION OF A NEW APPROACH METHOD FOR CIVIL DESIGN USING A CAD/CAM SYSTEM

This study provides a new approach method on Site Work Simulation using a CAD/CAM system. In an actual site yard, we have recognized that it is an important investigation to consider relationship between construction machines/robots and other them.

The following are showed the basical process flow on this method. (Fig 3-1)

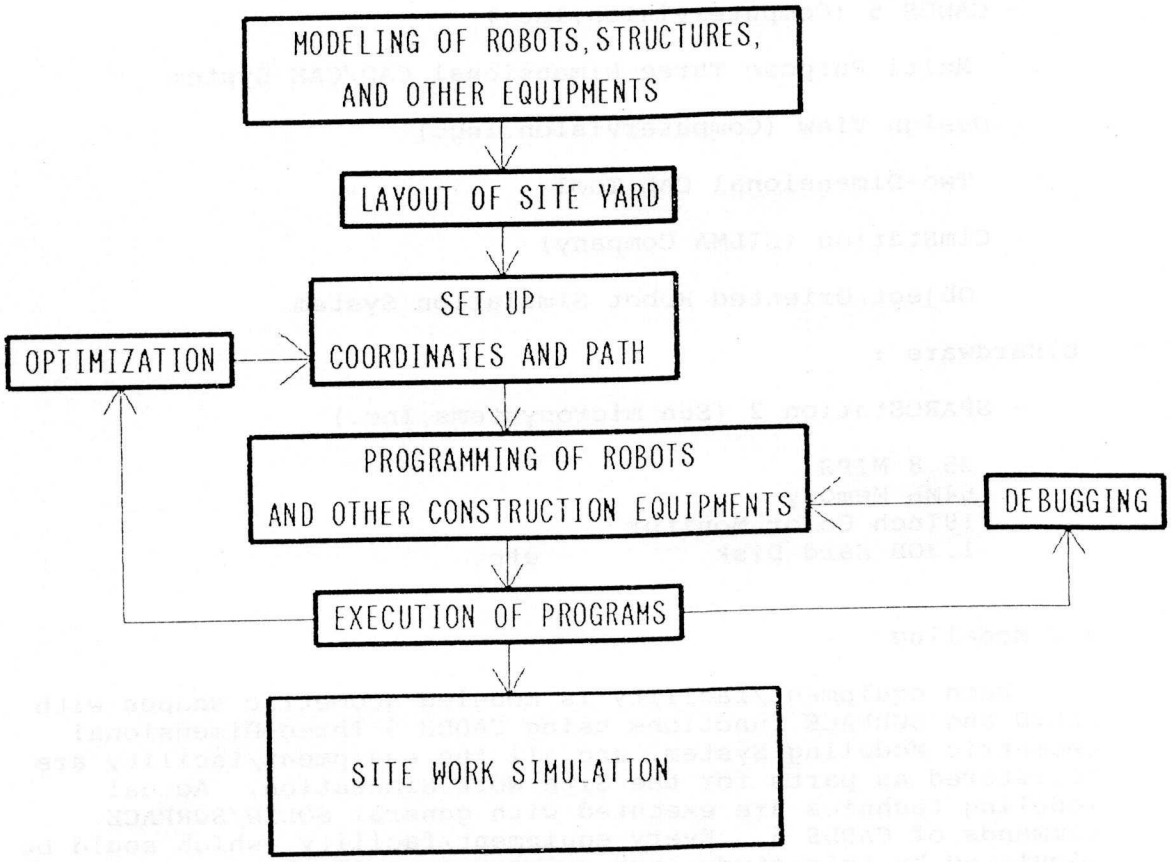

Fig 3-1 : The Basical Process Flow of Site Work Simulation

4. CONCEPT OF SITE WORK SIMULATION SYSTEM USING CAD/CAM SYSTEM

4.1 System Configuration

In order to investigate the Site Work Simulation, it is necessary to prepare some computer systems as Three-Dimensional CAD/CAM System.

The following is the system used by this study.

SYSTEM COMFIGURATION

a) Software :

- CADDS 5 (Computervision,Inc.)

  Multi Purpose Three-Dimensional CAD/CAM System

- Design View (Computervision,Inc.)

  Two-Dimensional CAE Tool

- CimStation (SILMA Company)

  Object Oriented Robot Simulation System

b) Hardware :

- SPARCStation 2 (Sun microsystems,Inc.)

  25.8 MIPS
  64MB Memory
  19Inch Color Monitor
  1.3GB Hard Disk etc.

4.2 Modeling

Each equipment/facility is modeled geometric shapes with SOLID and SURFACE functions using CADDS 5 Three-Dimensional Geometric Modeling System, and all the equipment/facility are registered as parts for the Site Work Simusation. Actual modeling technics are executed with general SOLID/SURFACE commands of CADDS 5. Every equipment/facility, which sould be simulated by this study, are created in this phase.

4.3 Layout of Site Yard

After each equipment(construction machine and robot) was defined, these equipments are located in the site yard using Layout Function of CimStation. As each equipment is registered as a library of the equipment parts, whenever they are able to be re-located repeatedly.

4.4 Programming

Each program is asigned a specific equipment, and is described by Object Oriented Language called SIL Language. The language is convenient in order to represent a behavior of each construction machine haveing every movements.

For example, if each function of an equipment, which is a range of movement, a velocity/acceleration of it, etc., is not over a limitation of the function, it is possible that the program is used every equiqments to simulate it, even if the program is for a specific equipment.

4.5 Multe-Processing

In an actual civil construction site, every construction machines are operating relatively in order to do excavating, loading, hauling, screeding, compacting, etc. So it is necessary to generate multiple programs, and each program is related to other programs in order to simulate a parallel processing between a machine and other machines.

In general, every equipments (e.g., construction machines and robots in the site) are operated relatively each other. In short, an equipment influences other construction machines. On the other hand, other construction machines give some influences toward the equipment.

When CimStation are used, all the programs are executed under a simulation environment as single language called the SIL, it is possible to control procedures which are already defined toward each equipment. This programming and debugging are able to be executed every task of them independently.

When each debugging of program is finished, a trial of each equipment is executed in the constructions site which is defined into the CAD/CAM system as a computer graphic image.

Using the multi-processing method, an optimized result which is simulated actual circumstances of the site is provided faster than operations of man.

5. CASE STUDY

5.1 Thema:(A Bridge Erection Simulation)

This study is showed a case of a Bridge Erection Simulation as Site Work Simulation. In general, a bridge erection work is occured various issues on some obstacles, e.g., site yard allocation issues, relationship between existing structures and the structure which should be built, interfarence checking between structures and equipments, etc.

5.2 Back Ground of Simulation

In this case, the bridge is needed to erect some beam members as an overpath without stop a railroad which is running beside the construcion site. In short, the sliding of the beam have to be executed while no train are existed on the line.

The construction is selected The Sliding Erection Method as a best way considering some limitaion issues in the site. This construcion is not allowed to spend enough times, and is limited the work time per a day in order to stride over the railroad. This construction is needed a very careful work, because this erection might have a cause of traffic accidents toward passengers of the trains, and is never allowed a fault for safety.

In like this case, we need to consider a best way for the executed constrution in advance using some inteligent condsideration tools.

5.3 Solution Using CAD/CAM System

Using the CAD/CAM System we have studied, we have tried to forcast some factors of risk under the construction, and have simulated a sequence of the erection.

a) Modeling of Structures Using CADDS 5/CimStation

Actual shapes of the bridge structures are modeled with SOLID/SURFACE Functions using CADDS 5. It means a definition of site yard. (Fig 5-1,2)

b) Definition of Construction Machines Using CimStation

It is defined movements toward each element of the machine. The movements are showed rotating, stretching, bending, etc. It is avalable to use Object Oriented Language, SIL. (Fig 5-3,4)

c) Erection Simulation Using Multe-Process Method

It is possible to make this system execute multiple processed at the same time. (Fig 5-5,6,7, Appendix A)

6. CONCLUSION

We have been able to simulate a site work using the CAD/CAM system in advance, before the site project is started, It is very significant to be able to simulate the behavior of site in advance. For example, it is possible to avoid from some risks, or optimize for construction prices, or reduce the construction period, etc.

This study is a mere trial to consider the optimization for Site Work Planning. We belive, however, that the use of this Object Oriented Three-Dimensional CAD/CAM system as Site Work Simulation System is needed to consider their methods in the future for Construction Industry in the world.

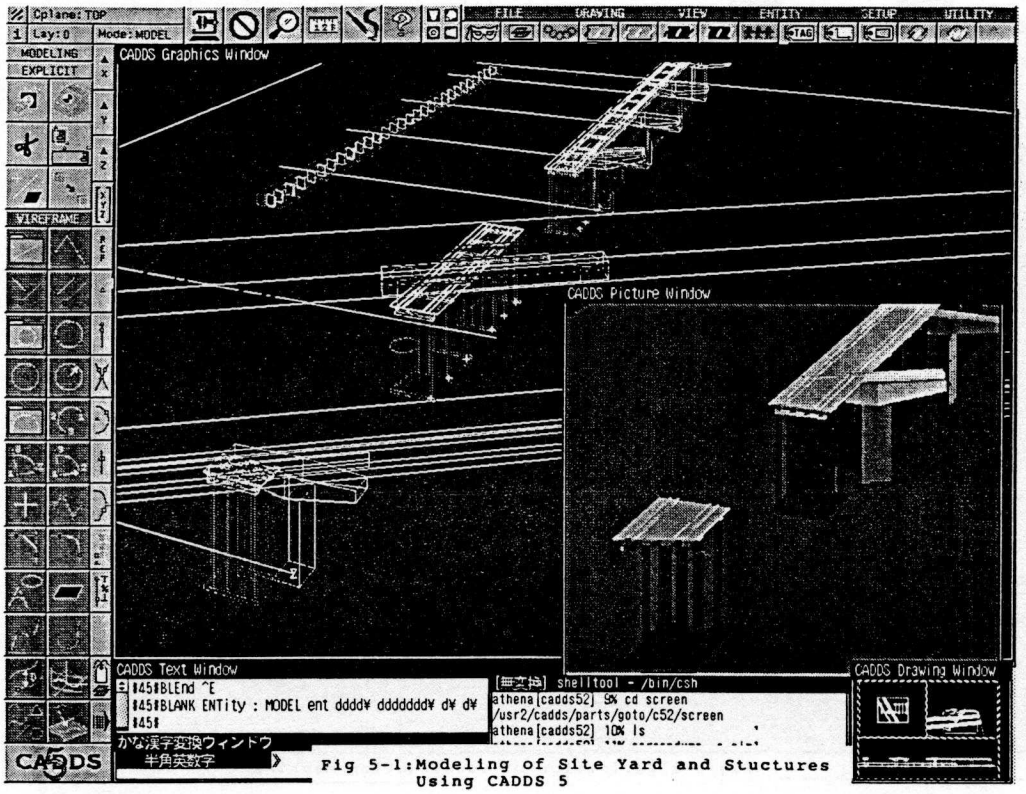

Fig 5-1:Modeling of Site Yard and Stuctures Using CADDS 5

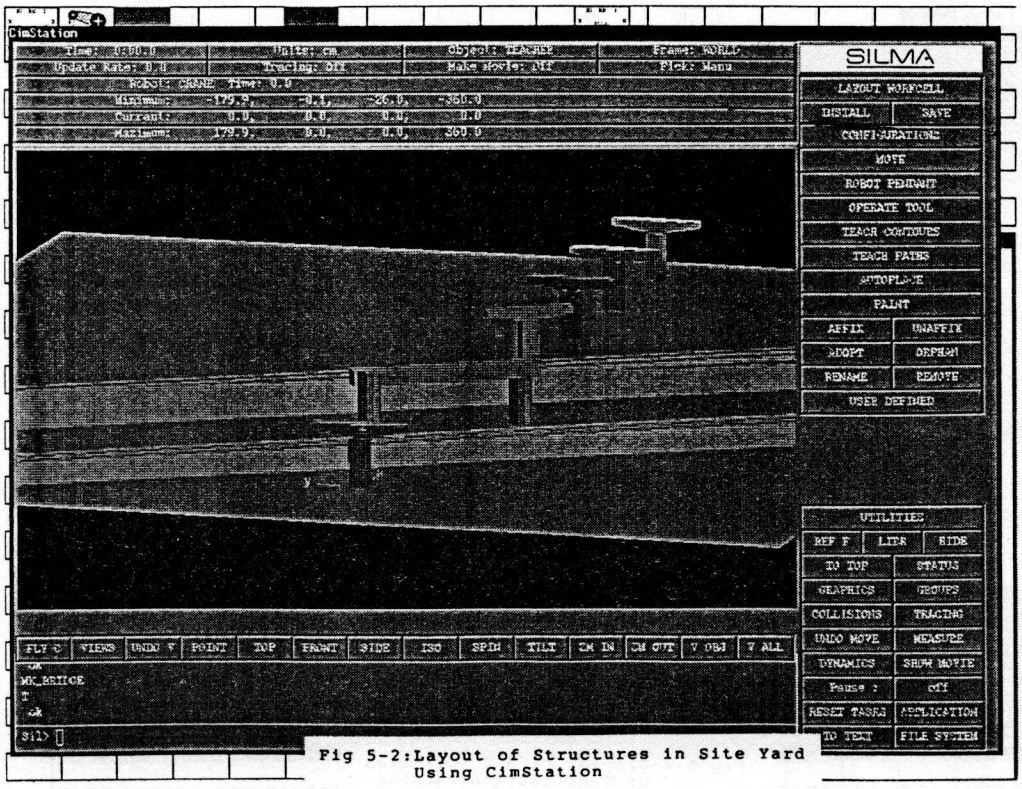

Fig 5-2:Layout of Structures in Site Yard Using CimStation

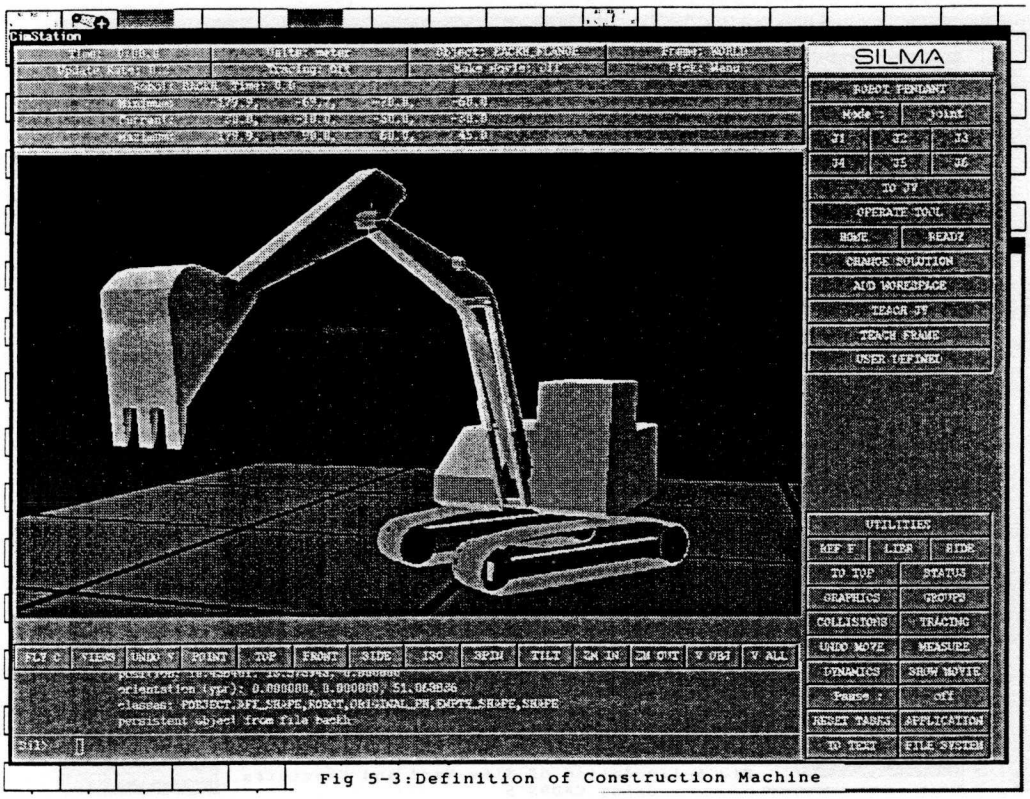

Fig 5-3:Definition of Construction Machine

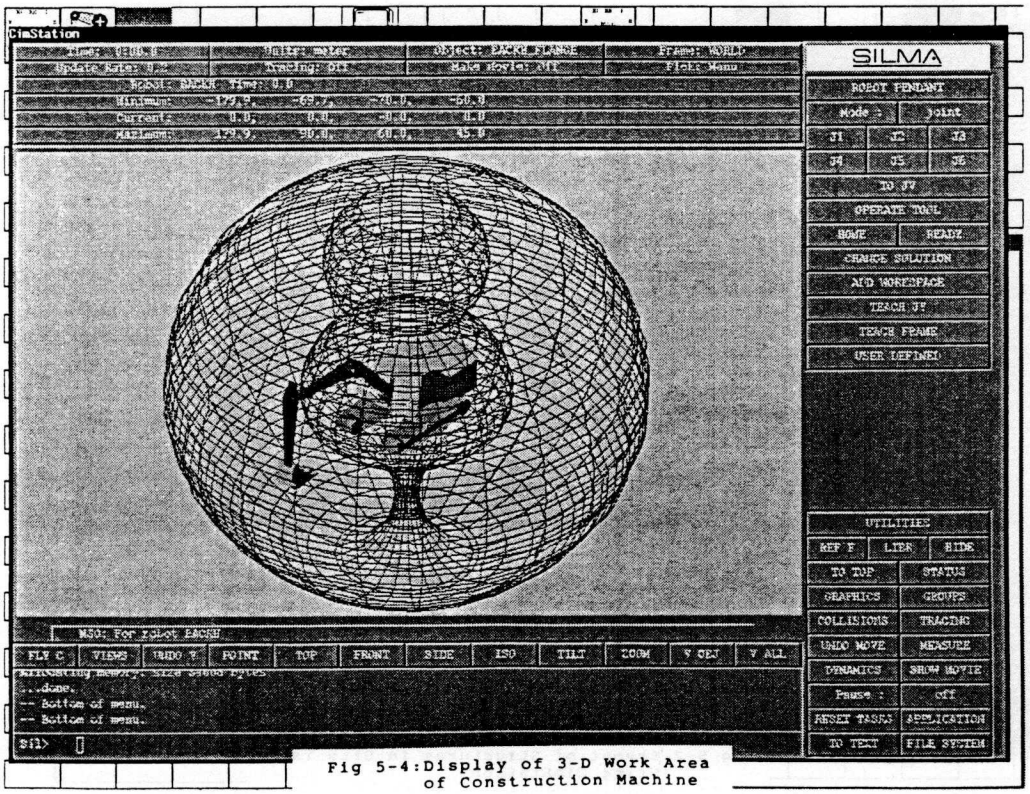

Fig 5-4:Display of 3-D Work Area
of Construction Machine

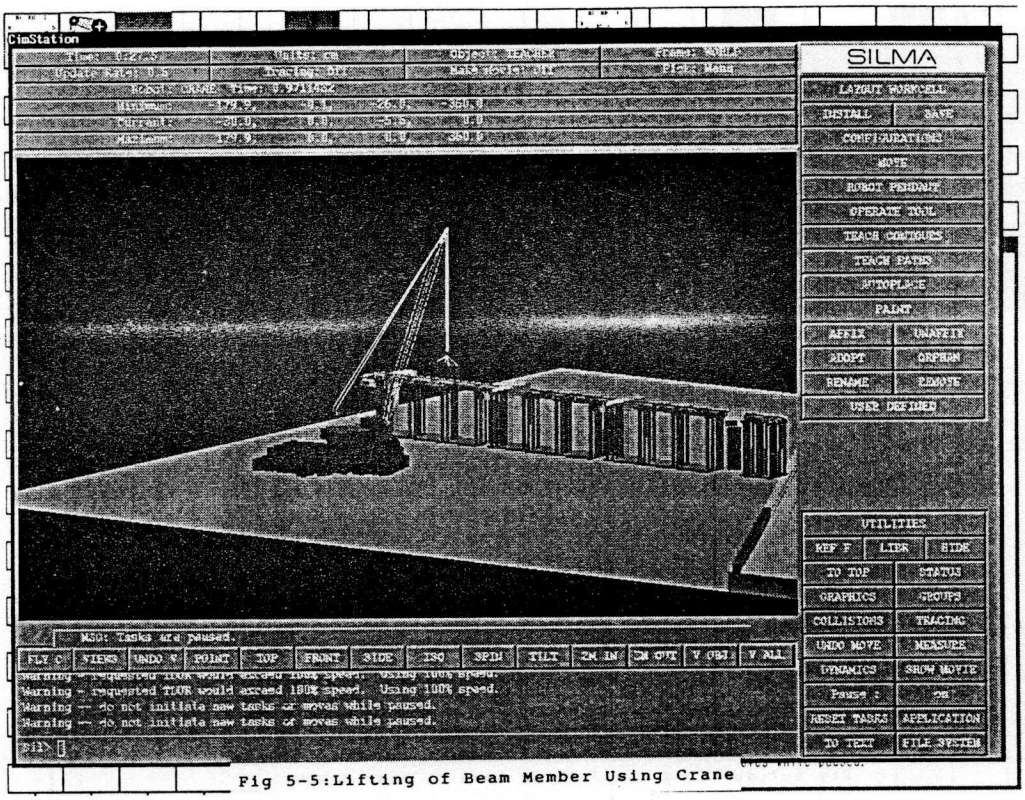

Fig 5-5:Lifting of Beam Member Using Crane

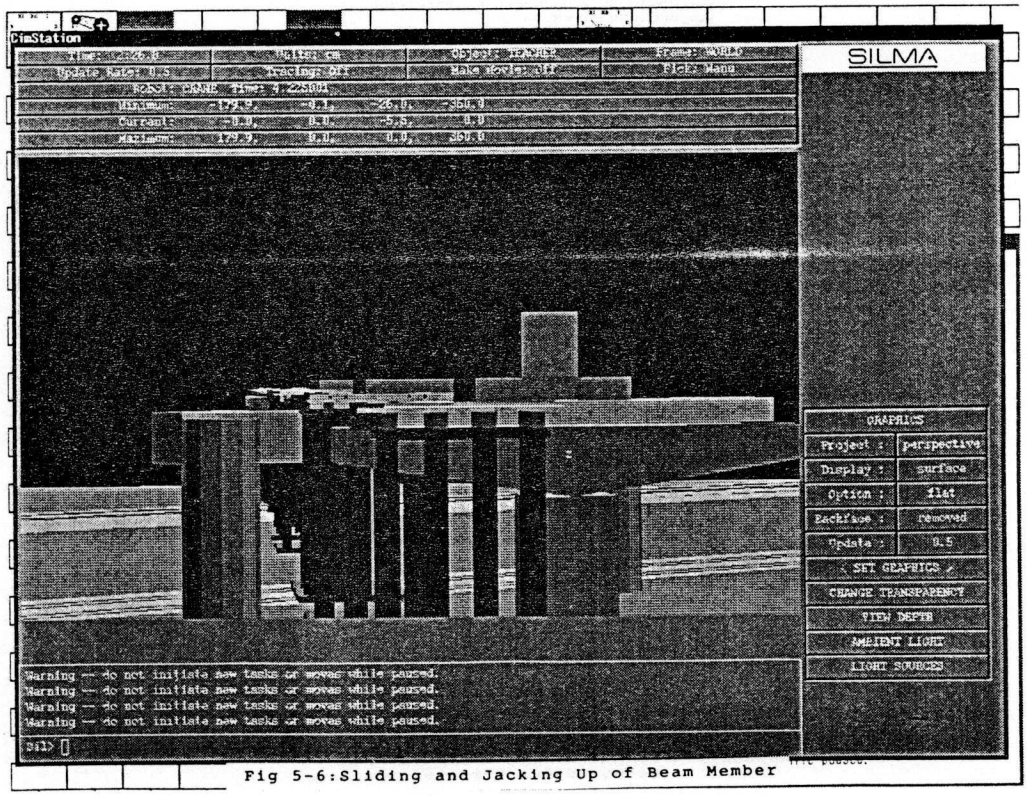

Fig 5-6:Sliding and Jacking Up of Beam Member

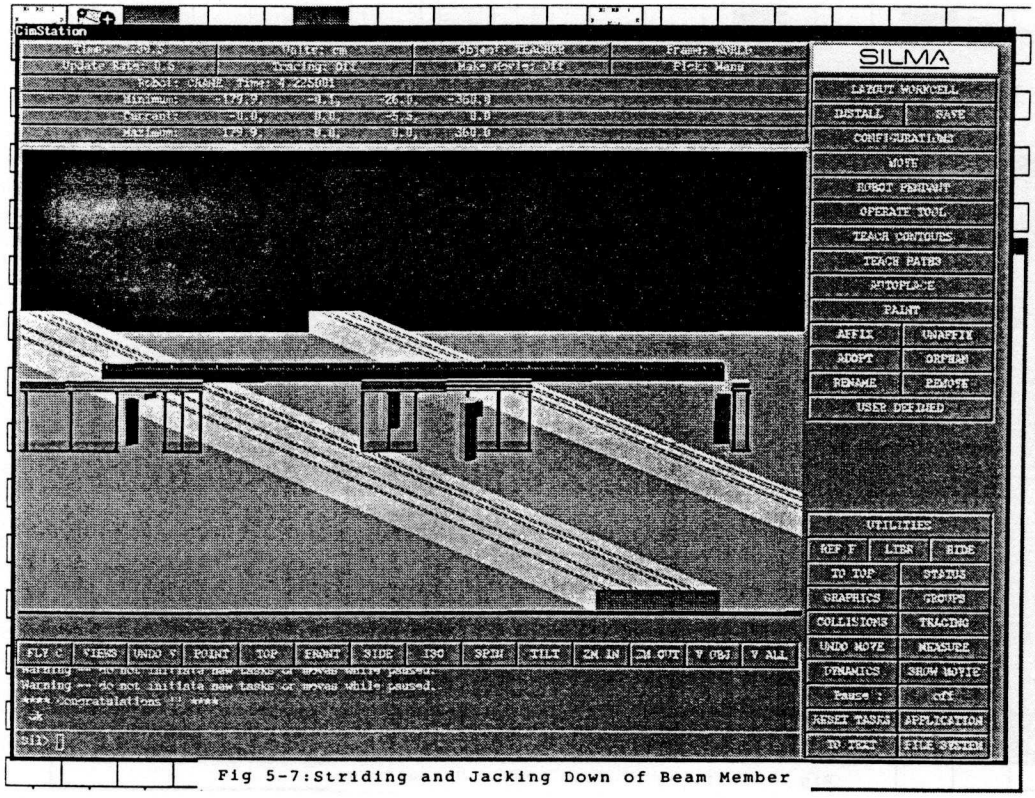

Fig 5-7:Striding and Jacking Down of Beam Member

```
process boxlen1();
begin
  look_from('tokai1');
  moveto_s('BOX/UNIT1/G10',mk_pose(120.450325,2.6,16.098751,0,0,-180));
  signal(set_dai_1,just_tokai,true);
end;

{  *** 台車をセット ***  }
process set_dai_1(just_tokai:boolean);
begin
  wait(just_tokai);
  delay(1);
    moveto('KOROKORO/KORO1',mk_pose(155.9,5,15.1,0,0,0));
    moveto('KOROKORO/KORO2',mk_pose(205.9,5,15.1,0,0,0));
    moveto('KOROKORO/KORO3',mk_pose(80,5,15.1,0,0,0));
    moveto('KOROKORO/JACK',mk_pose(78.9,5,15.1,0,0,0));
  unhide('KOROKORO/KORO1');
  mark(mk_point(155.9,5,15.1),'DAISYA-1 set');
  c_ob('KOROKORO/KORO1');
  delay(2);
  unmark_all();
  c_ob('teacher');
  unhide('KOROKORO/KORO2');
  mark(mk_point(203.9,5,15.1),'DAISYA-2 set');
  c_ob('KOROKORO/KORO2');
  delay(2);
  unmark_all();
  c_ob('teacher');
  affix('BOX/UNIT1/G10','KOROKORO/KORO1');
  affix('BOX/UNIT1/G10','KOROKORO/KORO2');
  start(firstmove);   {  東海道線上の最初の押し出し作業開始  }
end;

process firstmove();
var t_lp : integer;
begin
  t_lp:=0;
  focal_length(100);
  while(t_lp<5) do
  begin
    if tokai_exist then
     begin
       delay(0.01);
     end
    else
     begin
       moveto_s('BOX/UNIT1/G10',mk_crt(7.6,0,0) rel pose_of('BOX/UNIT1/G10'), 1.0 as tdur);
       t_lp:=t_lp+1;
     end;
  end;
  moveto('lens',mk_pose(105.927,4492.595215,14.800377,89.978615,0,-179.952271));
  focal_length(111.440926);
  t_lp:=0;
  unaffix('KOROKORO/KORO1','BOX/UNIT1/G10');
  unaffix('KOROKORO/KORO2','BOX/UNIT1/G10');
  unhide('KOROKORO/JACK');
  start(brot,kjup);
end;

{  J UP  }
process brot();
begin
moveto_s('BOX/UNIT1/G10',mk_pose(82.450798,2.6,16.397002,0,-0.2,-180), 3.0 as tdur);
```

Appendix A:Sample of Multi-Processing
Using Object Oriented Language