# Wave effects on hinged bodies
# Part III – hinge loads vs. number of modules

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June 23, 1998

## 1 INTRODUCTION

At the Workshop on MOB Hydroelasticity held at NFESC on 27-28 May, a brief discussion took place concerning the relative vertical hinge loads of configurations with even or odd numbers of modules. Experiments were cited as evidence that an even number of modules leads to a relatively high load on the center hinge, compared to the off-center hinges associated with an odd number of modules.

This note, which is motivated by that discussion, extends the computations for a configuration with five modules reported in Part 2 of this series of papers. As in Parts 1 and 2, we consider as illustrative examples rectangular articulated barges with the modules arranged in a longitudinal array. The modules are connected by simple hinges with transverse axes. Each module has a length of 1200 feet, beam 500 feet, and draft 20 feet. Configurations are analysed with from two to eight modules and one to seven hinges. The total length is respectively from 2400 to 9600 feet.

Unlike the computations in Parts 1 and 2 based on WAMIT, the present computations have been performed with the higher-order program HIPAN, which has been extended to include generalized modes and to permit direct evaluation of the wave loads as explained in the closing paragraph of Part 2. The modes used are the same as those described in Parts 1 and 2, based on decomposition into symmetric and antisymmetric components about the center ($x = 0$) of the array. For the array with five modules the HIPAN and WAMIT computations have been compared for verification; these agree generally within three significant figures accuracy (based on the most accurate WAMIT computations with 2448 panels on one quadrant of the body). For the latter application the use of HIPAN results in a reduction of the number of unknowns from 2448 to 232, and a reduction in the CPU time of about 1/60.

The results are presented in Figures 1-7. Each figure corresponds to the configuration with 2-8 modules, respectively, and 1-7 hinges. Plots are shown for the shear force on each hinge, numbered from the stern toward the bow. Five wave headings are shown including 180° (head seas, propagating from the bow toward the stern), and four oblique headings (140°, 130°, 120°, and 110°) which are intended to indicate the maximum load conditions. In all plots the abscissa is the wave period in seconds, and the ordinate is the normalized shear force based on unit values of the wave amplitude, water density, and gravity.

## 2 DISCUSSION

In general the maximum hinge loads increase with increasing numbers of modules, especially for the smaller arrays with 2-4 modules. For the larger arrays the rate of increase is relatively small. The highest loads occur on the interior hinges (as opposed to the hinges nearest the bow and stern), and in oblique wave headings near 130° (corresponding to waves incident from 40° forward of the beam). There is not a substantial difference between the cases where the number of modules is even or odd, and for the larger arrays the maximum loads are similar on all of the hinges except for those nearest the two ends.

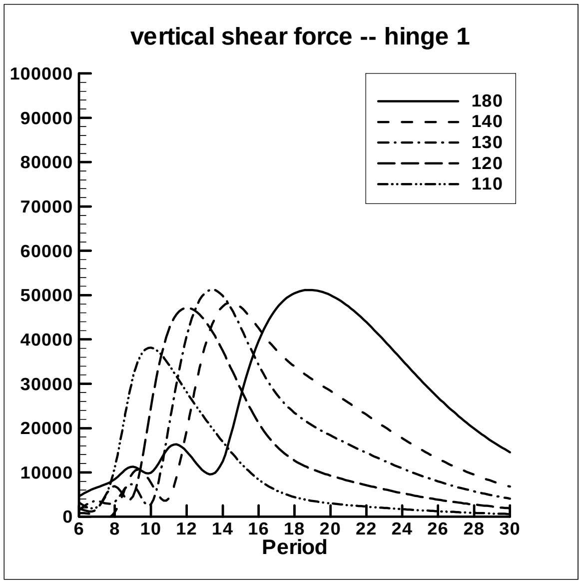


Figure 1: Hinge loads for $N = 2$ modules.

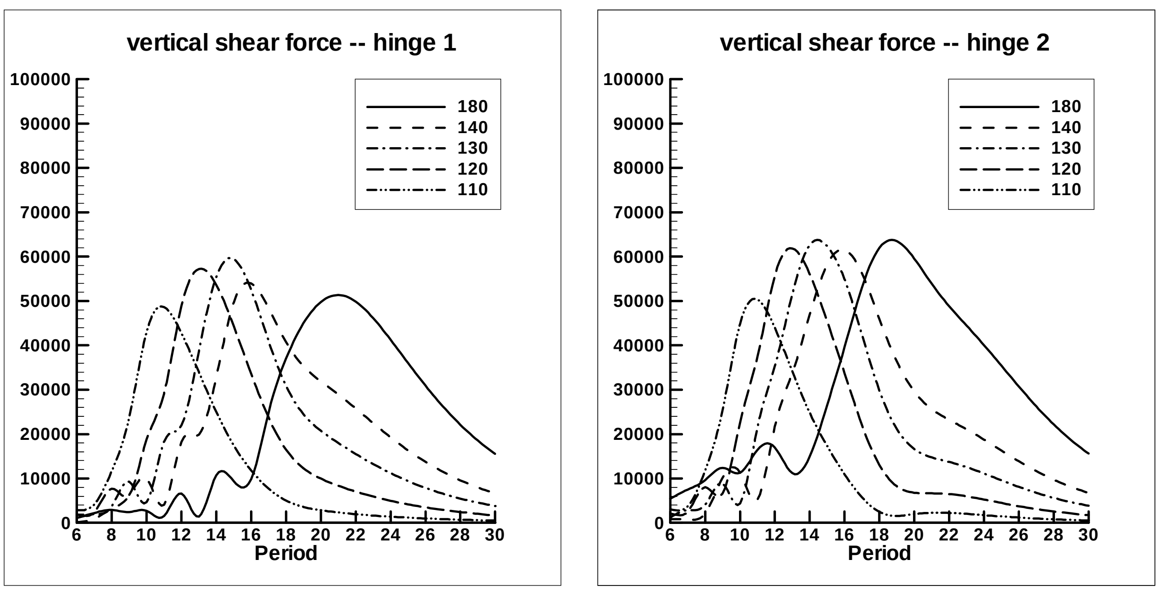


Figure 2: Hinge loads for $N = 3$ modules.

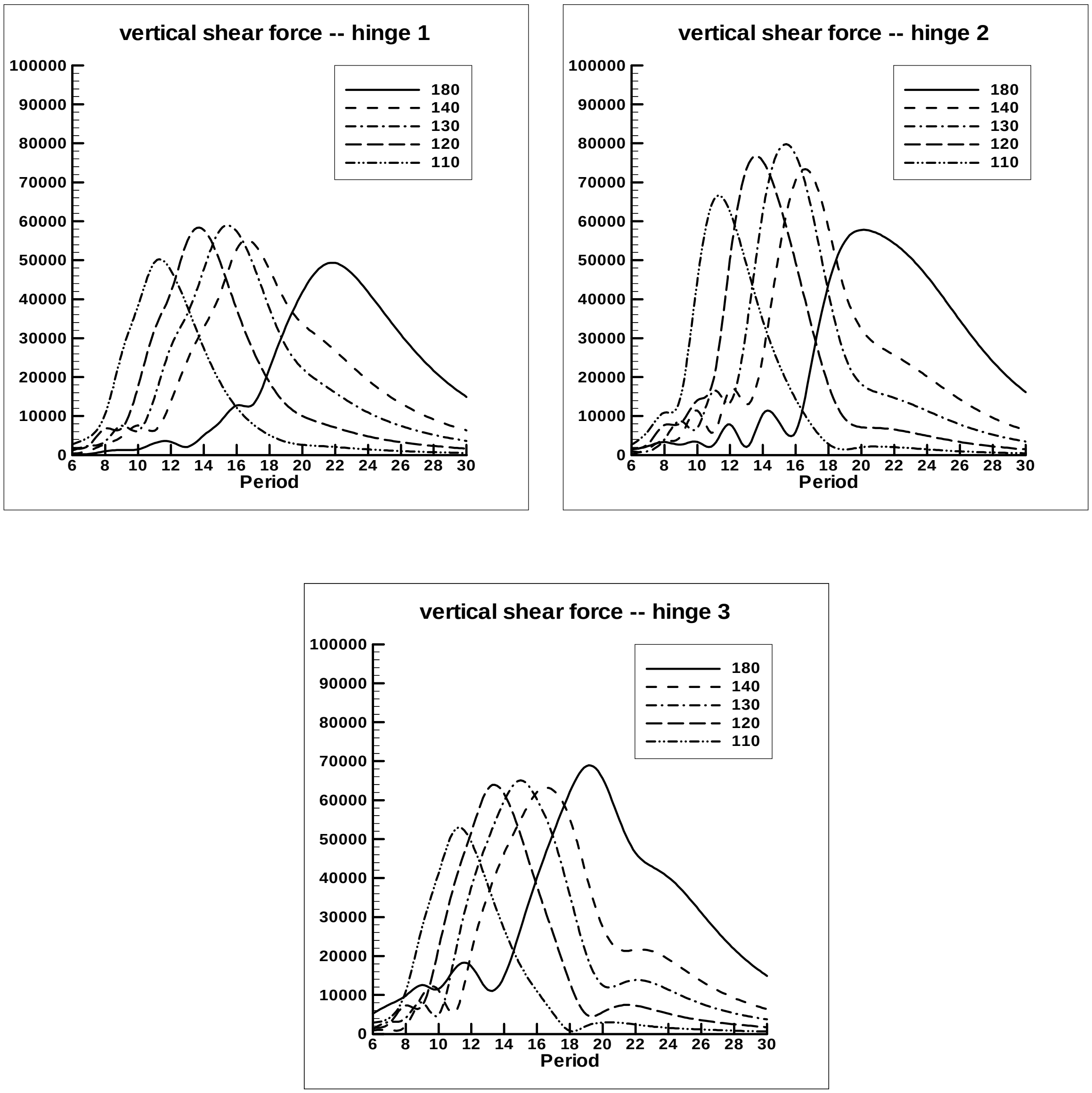


Figure 3: Hinge loads for $N = 4$ modules.

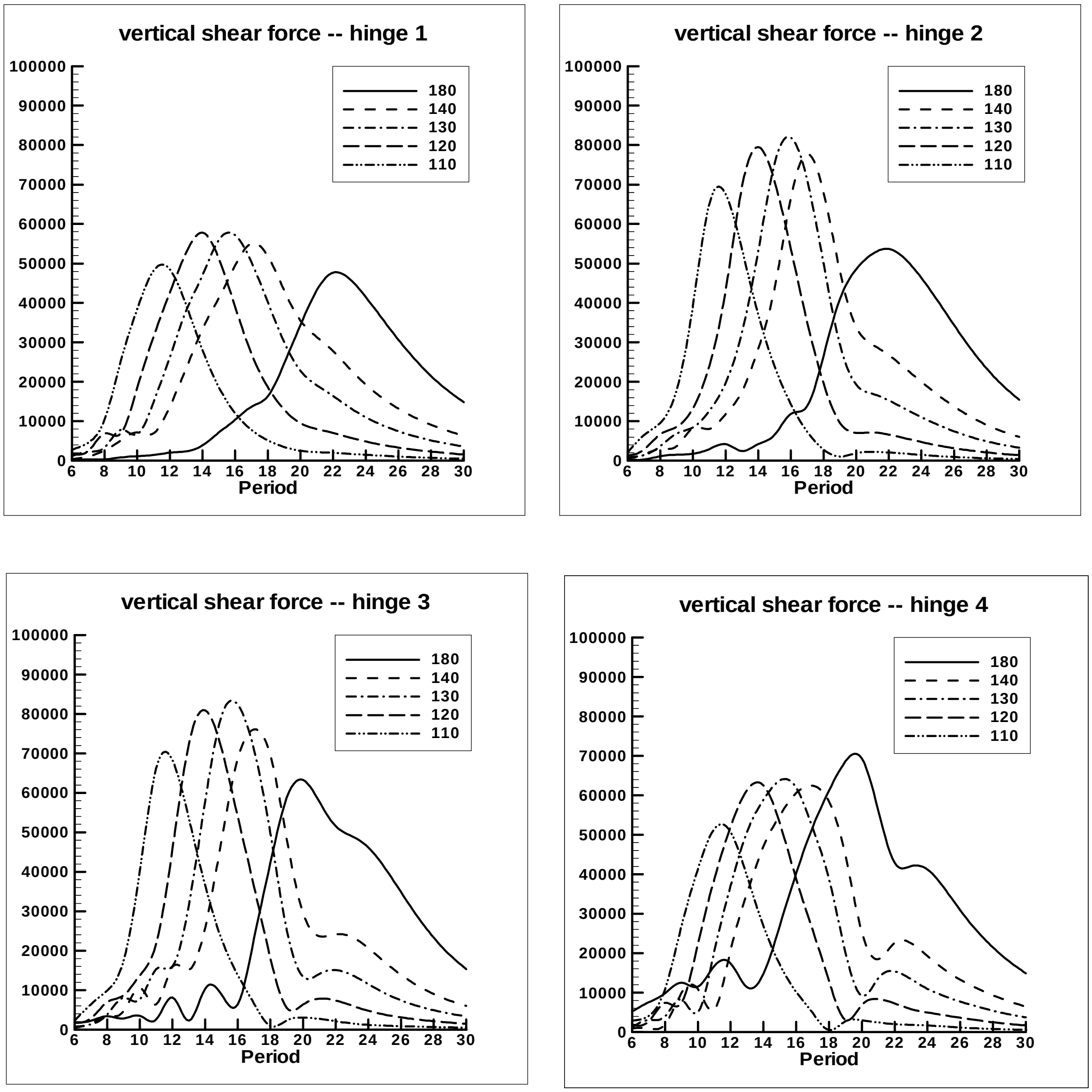


Figure 4: Hinge loads for $N = 5$ modules.

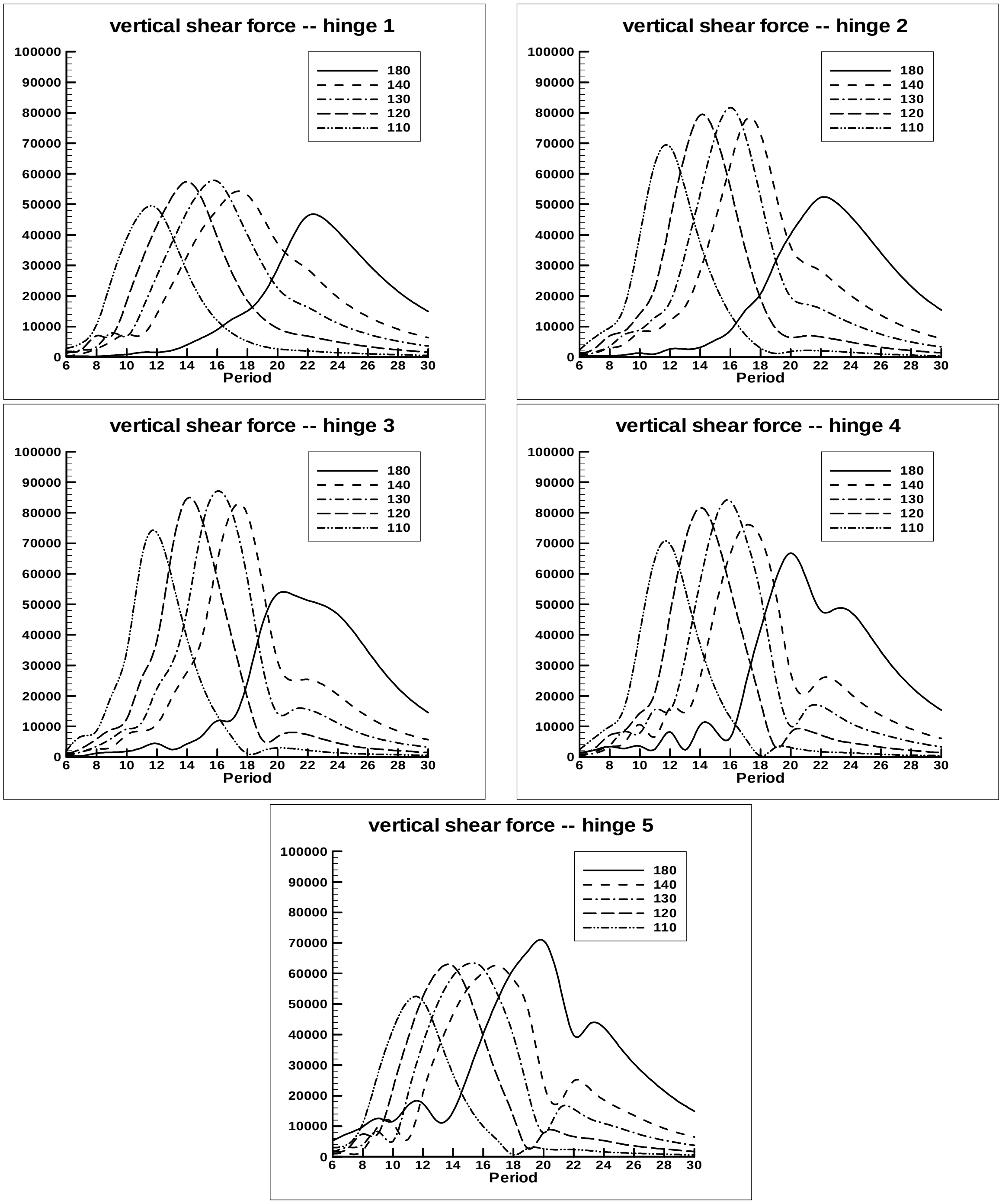


Figure 5: Hinge loads for $N = 6$ modules.

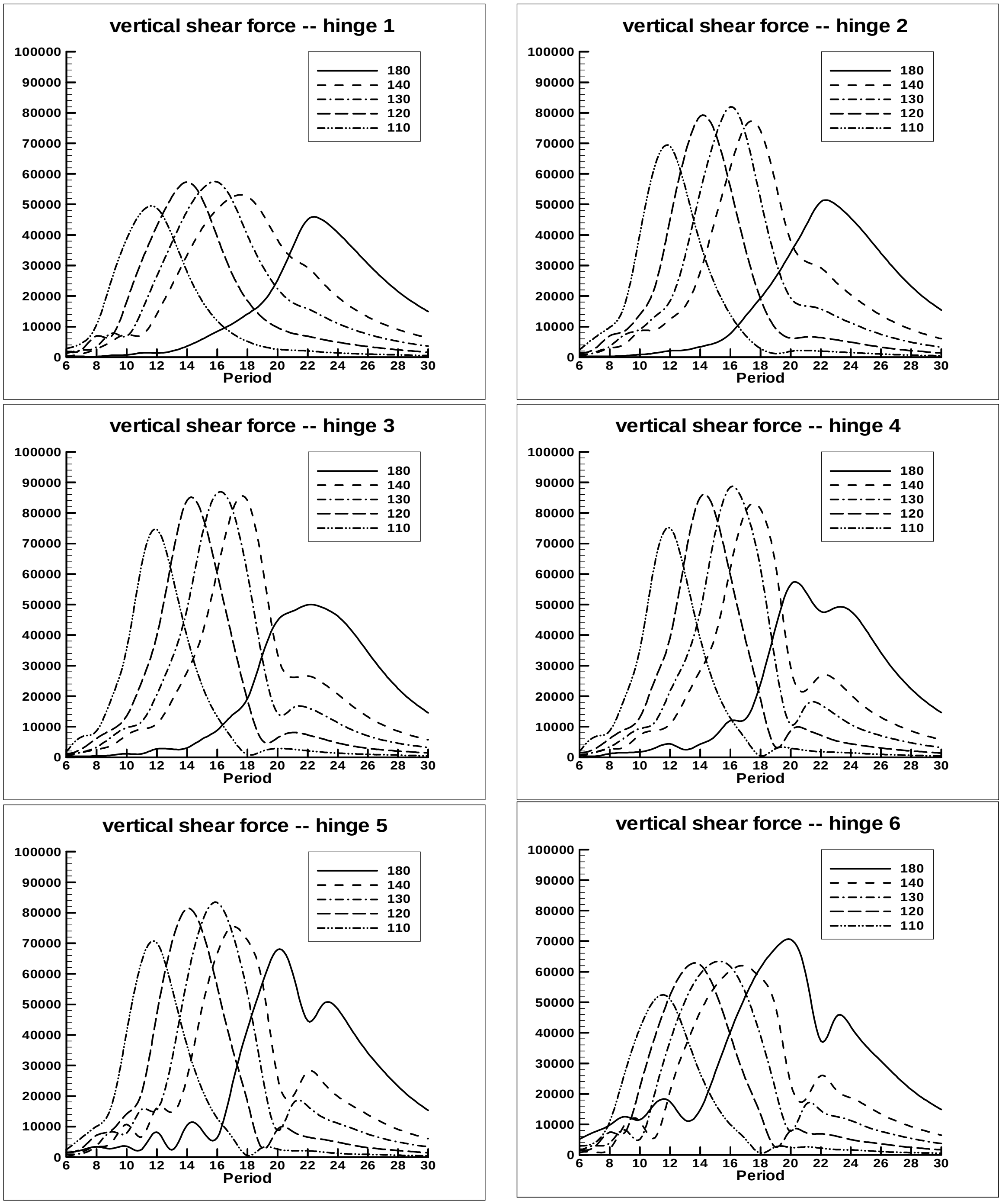


Figure 6: Hinge loads for $N = 7$ modules.

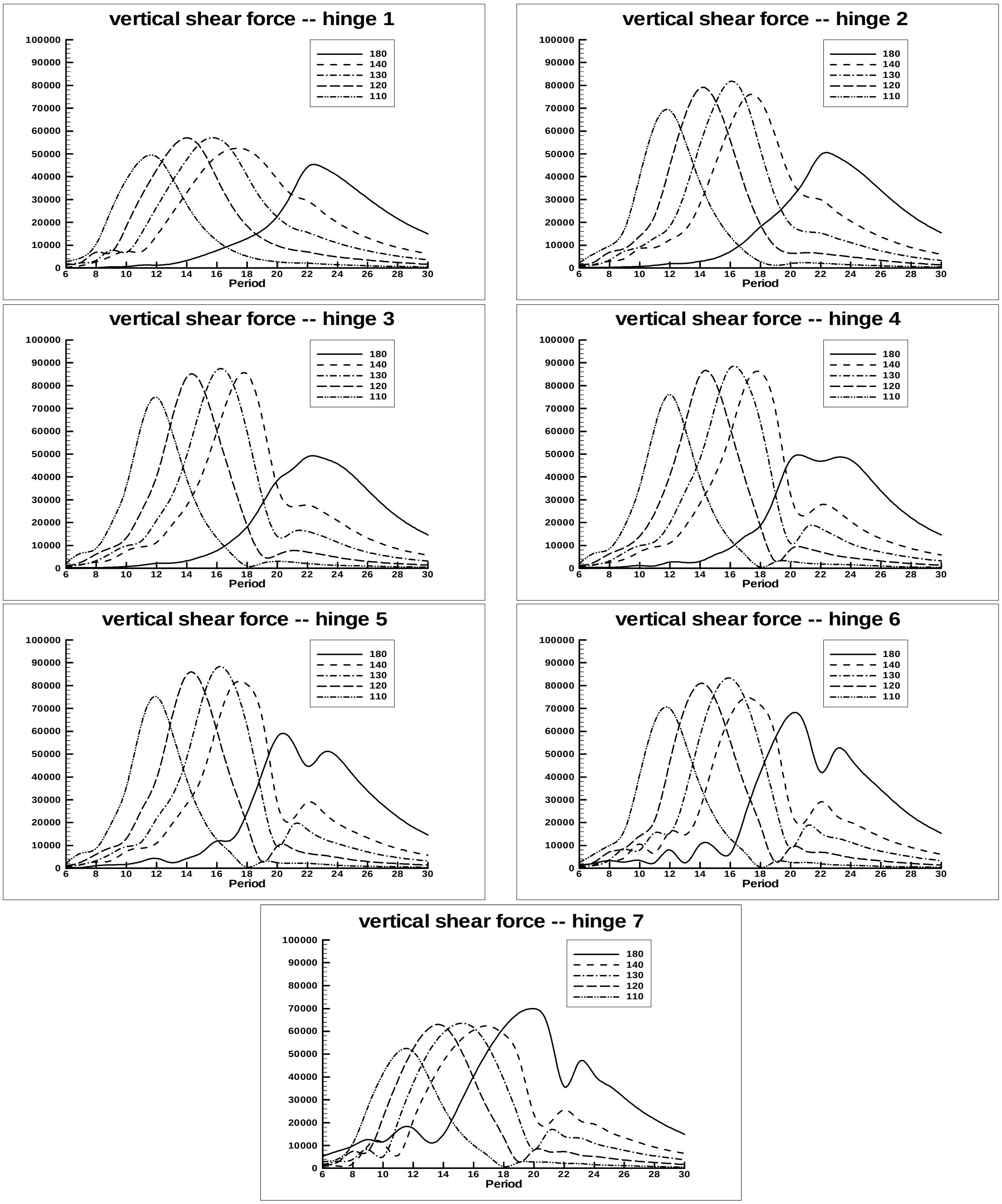


Figure 7: Hinge loads for $N = 8$ modules.