PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Liverpool Civic and Social Centre: Preliminary Wind Tunnel Testing to Determine Environmental Conditions

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Liverpool Civic and Social Centre: preliminary wind tunnel testing to determine environmental conditions

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A series of preliminary wind-tunnel tests have recently been carried out on a model of a proposed Liverpool Civic and Social Centre (for which the architect is Colin St J. Wilson). These tests were primarily concerned with investigating one aspect of the wind pattern around the building—how it affects the pedestrian. The value of initial, or exploratory, testing has been that the opportunity could be taken to use a short (2- or 3-day) availability of a wind tunnel, in this case offered to us by courtesy of the University Engineering Laboratories at Cambridge, to place in it an existing model of the scheme. From this has been obtained a guide to the types of detailed testing that will be necessary as the design progresses.

The form of the building complex in the study model (figures 1 and 2) can be separated out vertically into three main elements:

(i) Five upper floors of offices, which house 4500 members of the Corporation Staff and, in the centre block, connect to a public reception hall handling up to 8000 visitors on a normal day.

(ii) At mid-level a pedestrian route system across the site in the form of a covered arcade with attached commercial accommodation.

(iii) In the four to six lower levels of the podium a social and public realm with sports and swimming centres, restaurants, multi-purpose hall and adult education facilities.

The overall dimension of the pinwheel forming the upper office levels is 244 m (800 ft) from east to west and the centre hall section is 73 m (240 ft) square. The first testing of environmental conditions has been carried out on a 1/500 scale wood and polystyrene model which allows for the Civic Centre together with its immediate surrounding area of Liverpool to be assembled on a baseboard 1.3 m square.

In accepting the limitations of size of model and its surrounding, it was recognized that the questions we, as architects, needed to ask at the initial design stages were:

(i) What happens if this building form is interposed into an already open and windy site and what emphasizing of wind characteristics takes place?

(ii) Can information be obtained on where gusts or buffeting at pedestrian levels might make for uncertain conditions—especially those that would affect the young or the elderly?

(iii) Given the necessity for a boiler flue at a certain point in the scheme, what would be the likely direction of the smoke plume and its relation to nearby building?

The site is a predominantly open area in the form of a shallow valley from east to west. This has a fall of level of approximately 12 m from the plateau of St George's Hall, across the adjacent St John's Gardens, to the Mersey Tunnel approach area (figure 2). The edges of the site are surrounded by existing building varying from 12 m to 24 m high. The most frequently recorded wind directions are from the northwest sector in spring and summer, the southeast sector in autumn and winter, while the strongest local winds have been recorded from the west-southwest. We were in fact extremely fortunate that this, and other very relevant information, was already

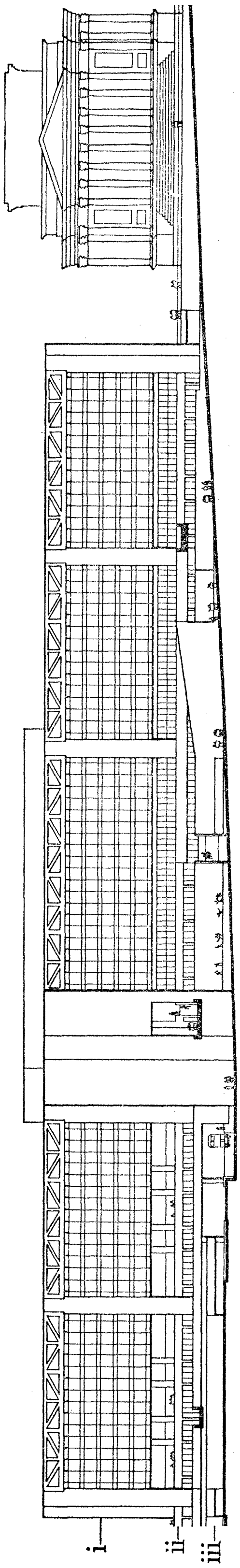

Figure 1. Section east–west across site showing Civic Centre and, on the right, St George's Hall: (i) offices, (ii) arcade, (iii) social.

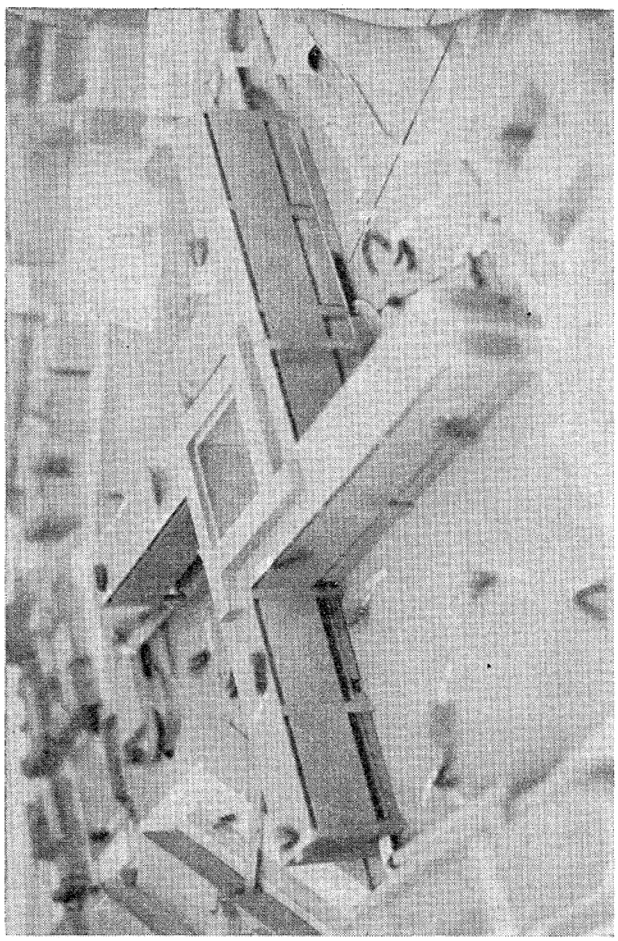

Figure 3. 1/500 model under test with marker tabs within wind tunnel. View from north.

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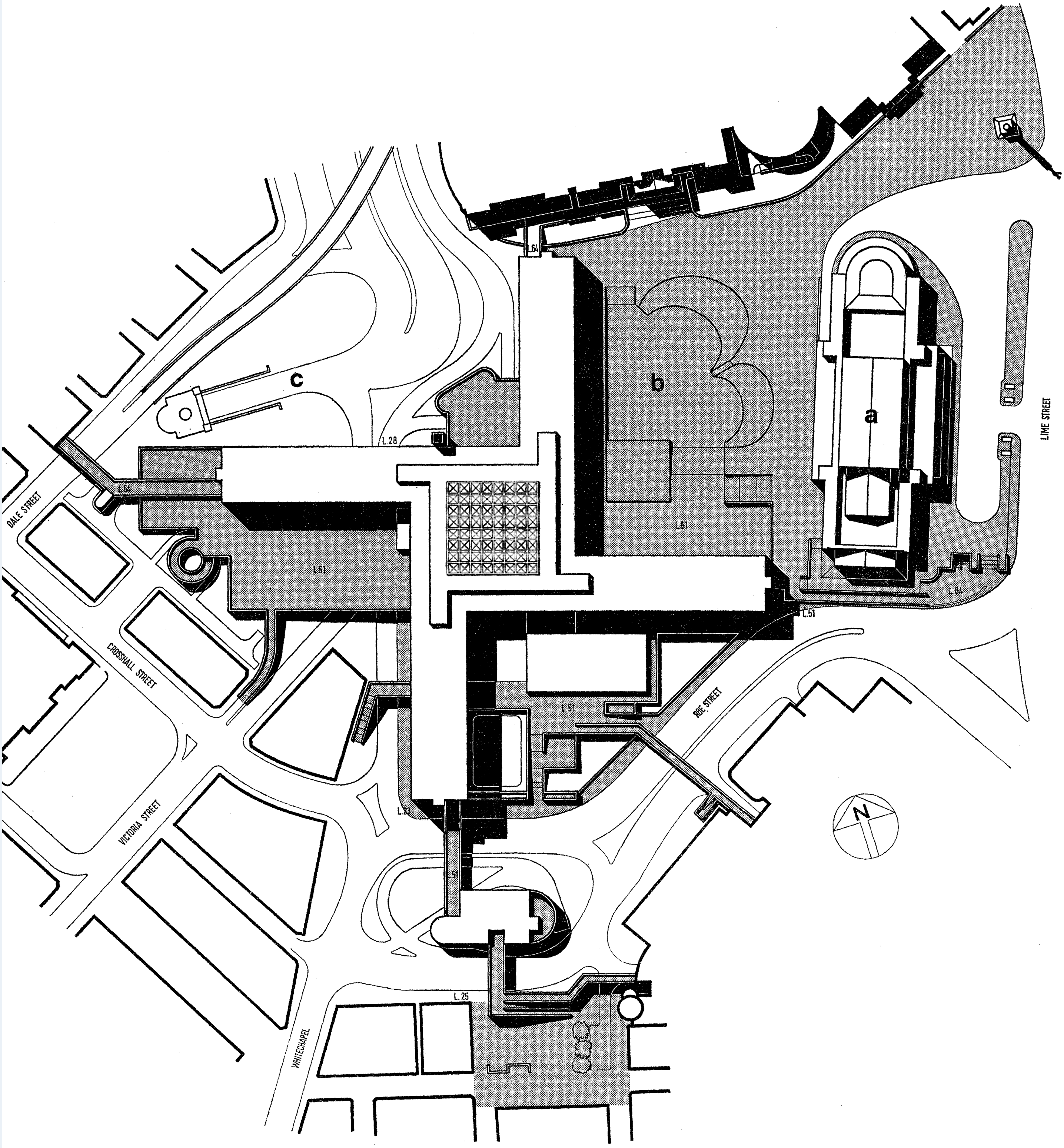

Figure 2. Site plan of Liverpool Civic and Social Centre: (*a*) St George's Hall, (*b*) St John's Gardens, (*c*) Mersey Tunnel entrance.

available to us in a comparison study of full scale and model wind flows for the identical St John's Gardens site. This had been carried out independently by Jones & Wilson (1967) where the authors documented their experience with a similar scale 1/500 model of the Liverpool central area landscape.

The wind tunnel made available at the Engineering Laboratories, Cambridge, has a usable floor width of 1.67 m and a height of 1.2 m and the tests there were carried out for us under the direction of Dr D. J. Maull. These tests used 2 cm woollen tab markers taped to the model at all relevant locations to record flows from an air speed of 9 to 12 m/s uniform across the tunnel (figure 3). Under these conditions the degree of flutter and rotation of the marker tabs indicated the likely amounts of turbulence to be expected. At the scale of the model it must however be noted in the following results that a pedestrian represents rather less than 5 mm high, and it is in this critical zone that interest has finally of course to focus—whereas the woollen markers may also be indicating general wind conditions up to 6 or 9 m above ground level.

The directions of air currents at deck level, particularly in St John's Gardens and along pedestrian routes, were noted for each test together with points of marked 'unsteadiness' where sudden changes of wind direction might be expected. The results from *test no.* 1 with the prevalent wind from the northwest, showed that:

(i) Unsteady conditions at the link between the pedestrian arcade at the end of the east wing and the exposed podium of St George's Hall. (At this point the marker tab was rotating almost vertically.)

(ii) A similar position at the end of another wing, in this case the link between the north wing and the College of Technology, also proved to have gusting and uncertain air flows.

At the end of each test the air speed was lowered to approximately 3 m/s and smoke blown up through the boiler flue to simulate the likely direction of the plume. Although the buoyancy of the plume was not modelled, and hence the height might be inaccurate, we watched this point carefully and in this test (no. 1), with the given flue height, the smoke was well clear of the roof of the north wing and Central Hall.

Test no. 2 then modelled the wind from the west-southwest sector from which the strongest local winds may be expected:

(i) The first and most immediate result of the change of wind direction was that, while there were still unsteady conditions at the end of the east wing, these were now extended into St John's Gardens giving sudden alterations of wind direction likely along the west face of St George's Hall, and more turbulent conditions in the centre of the gardens. This appeared to be the result of air flows coming down over the Centre and east wing meeting those of a contrary direction being drawn out of the space to seek reattachment around the south facade of St George's Hall.

(ii) Other points of flashing from the marker tabs indicated that attention must also be paid to a potential vortex within the south sector where there is an ice rink and a sports centre.

(iii) The smoke plume could be seen in this test to just come down onto the north wing and might therefore be a source of trouble for the ventilation of the roof level plant rooms.

We also carried out the same test with additional office expansion wings added in parallel (*test* 4). The apparent influence of the extra east wing was to improve conditions slightly in the centre of St John's Gardens and break up any potential vortex in the south sector. The opportunity was also taken, in tests when the extra wings were added, to increase the flue height to approximately 12 m above general roof level, at which height the smoke plume was quite clear of being blown down onto the roof.

In the final *tests* 3 *and* 5 the other prevalent wind direction, from the southeast sector, was then modelled and further sets of variations for the ground condition recorded. These showed, for instance, a reduction of turbulence around St George's Hall but introduced a new element—the very strong channelling of wind straight along the south face of the east wing towards the pedestrian activities in the inner corner of the south sector.

In any evaluation, however, of this first series of tests we recognized that the results are in the form of gross effects giving an early warning of probable trouble areas. From these, more detailed wind tunnel work on the Liverpool design can now take place with large scale models to try out alternative built forms for low level and surface details. Areas which have perhaps appeared turbulent at this 1/500 scale may well be completely amended for the pedestrian by the design of barrier sections, ground contouring or planting.

The gross effects also show where questions must now be asked requiring a specific level of quantification in the answers, i.e. if wind conditions appear bad what are the speeds in relation to the free air stream and how do these relate to acceptable environmental levels on the Beaufort wind scale (see, for example, White 1968). For such quantification it will now be necessary to decide in what type of wind tunnel to model the main series of tests, what systems of profiling and shear should be incorporated to best simulate the incident wind flow and at what scale building models should be made to accept the most suitable instrumentation.

References (Taylor)

Jones, P. M. & Wilson, C. B. 1967 *Wind flow in an urban area*. London: Construction Industry Research and Information Association.

White, K. C. 1968 Studies for proposed town centre development at Corby in Symposium on wind effects on building and structures. Loughborough University of Technology.

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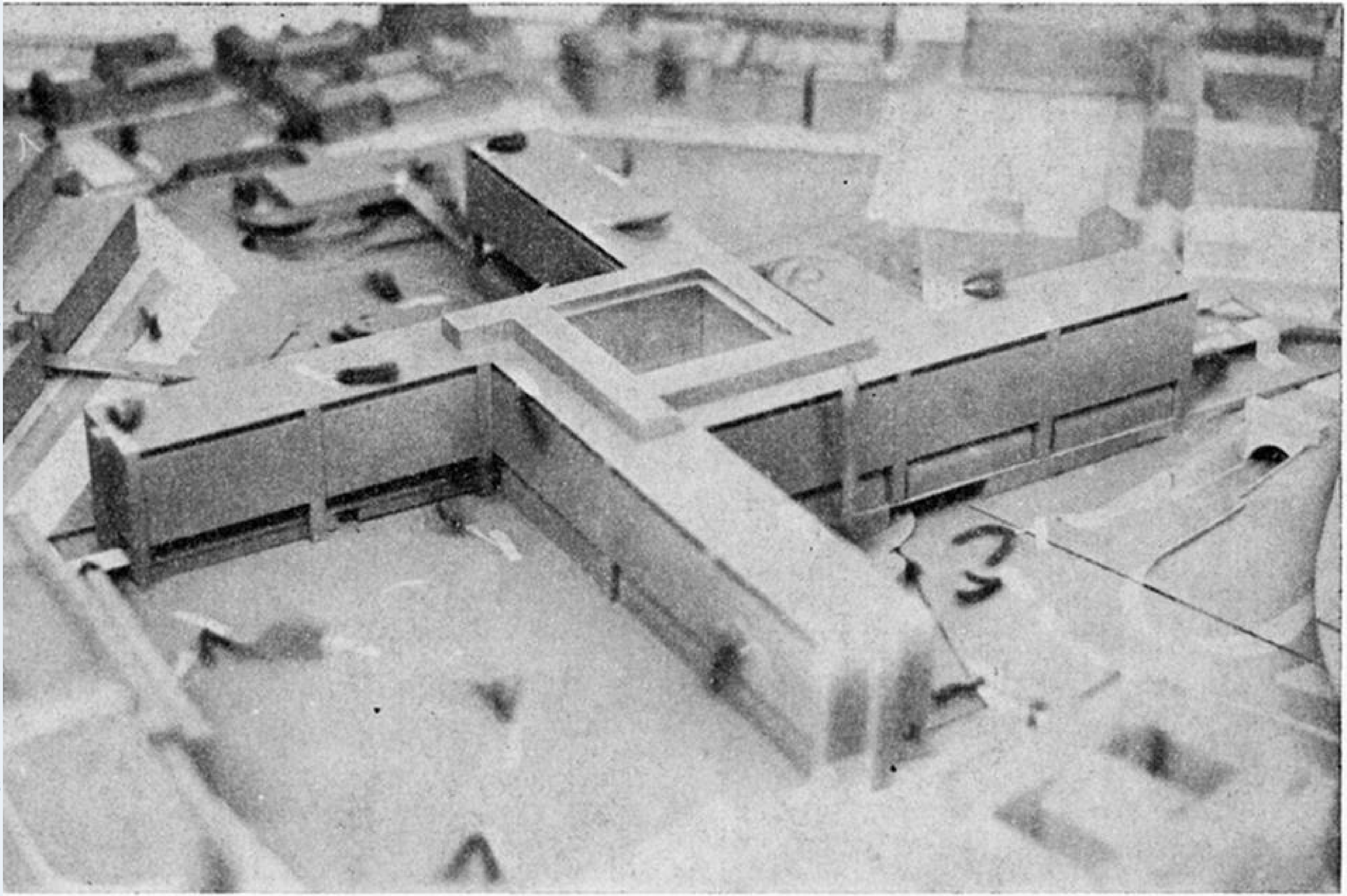

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